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Total Suspended Particulate Trend Sites, 1977-1986

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16. ABSTRACT

This report presents national and regional trends in air quality from 1977 through 1986 for total suspended particulate, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and lead. Air pollution trends were also examined for the 5-year period (1982-86). Both national and regional trends in each of these pollutants are examined. National air quality trends are also presented for both the National Air Monitoring Sites (NAMS) and other site categories. In addition to ambient air quality, trends are also presented for annual nationwide emissions. These emissions are estimated using the best available engineering calculations; the ambient levels presented are averages of direct measurements.

This report also includes a section, Air Quality Levels in Metropolitan Statistical Areas (MSAs). Its purpose is to provide interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information. Air quality statistics are presented for each of the pollutants for all MSAs with populations exceeding 500,000 for the years 1984, 1985 and 1986.

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DISCLAIMER

This report has been reviewed by the Office of Air Quality Planning and Standards, U. S. Environmental Protection Agency, and has been approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use.

PREFACE

This is the fourteenth annual report of air pollution trends issued by the U. S. Environmental Protection Agency. The report is prepared by the Technical Support Division, formerly the Monitoring and Data Analysis Division, and is directed toward both the technical air pollution audience and the interested general public. The Division solicits comments on this report and welcomes suggestions on our trend techniques, interpretations, conclusions, and methods of presentation. Please forward any response to William F. Hunt, Jr., (MD-14) U. S. Environmental Protection Agency, Technical Support Division, Research Triangle Park, N. C. 27711.

The Technical Support Division would like to acknowledge William F. Hunt, Jr., for the overall management, coordination, and direction given in assembling this report. Special mention should also be given to Helen Hinton and Cathy Coats for typing the report.

The following people are recognized for their contributions to each of the sections of the report as principal authors:

Section 1 - William F. Hunt, Jr. and Thomas C. Curran
Section 2 - Warren P. Freas
Section 3 - Thomas C. Curran, Robert B. Faoro, Neil H. Frank, and Warren P. Freas
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Section 5 - Stan Sleva, Neil Berg, Ed Hanks, David Lutz, George Manire, and Dennis Shipman

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As a final acknowledgement, it should be noted that this is the last EPA Air Quality Trends Report that will be done using EPA's SAROAD (Storage and Retrieval of Aerometric Data) system. SAROAD has been replaced by a more modern system that will be used for future reports. The Monitoring and Reports Branch would like to thank all of the people associated with SAROAD over the years, particularly our colleagues in the National Air Data Branch and their predecessors, for the design, development, implementation, and maintenance of a data system that made these reports possible.

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NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1986

EXECUTIVE SUMMARY

NATIONAL AIR QUALITY AND EMISSIONS TRENDS REPORT, 1986

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Although considerable progress has been made controlling air pollution, it still remains a serious public health problem. In order to protect the public health and welfare, the U.S. Environmental Protection Agency (EPA) has promulgated National Ambient Air Quality Standards (NAAQS). Primary standards are designed to protect the public health, while secondary standards protect the public welfare, as measured by the effects of air pollution on vegetation, materials and visibility. This report will focus on comparisons to the primary standards in effect in 1986 to examine both changes in air pollution levels over time, as well as current air pollution status.

In 1986, 75.0 million people were living in counties with measured air quality levels that violated the NAAQS for ozone (O_3) (Figure 1-1). This compares with 41.7 million people for total suspended particulate (TSP), 41.4 million people for carbon monoxide (CO), 7.5 million people for nitrogen dioxide (NO_2), 4.5 million people for lead (Pb) and 0.9 million people for sulfur dioxide (SO_2). While millions of people continue to breathe air that is in violation of the NAAQS, considerable progress is being made in reducing air pollution levels.

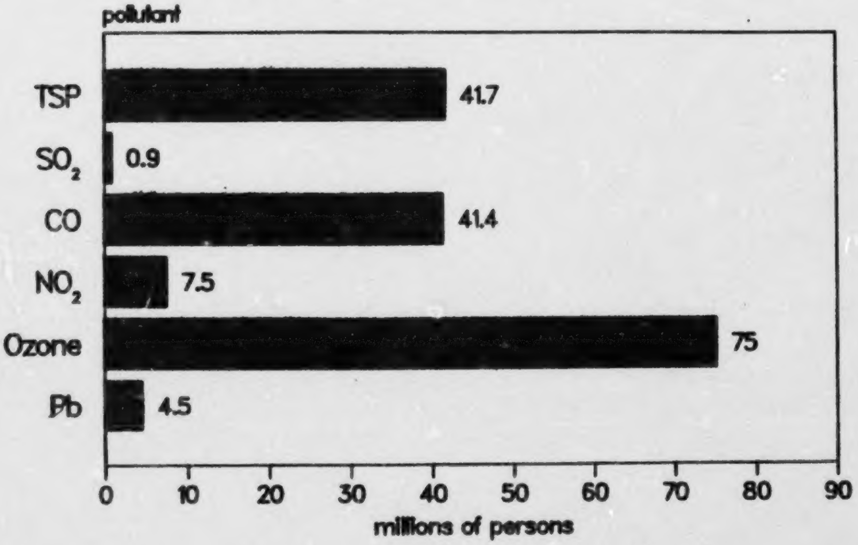

Figure 1-1. Number of persons living in counties with air quality levels above the primary National Ambient Air Quality Standards in 1986 (Based on 1980 population data).

Nationally, long-term 10-year (1977 through 1986) improvements can be seen for TSP, SO_2, CO, NO_2, O_3, and Pb. Similar improvements have been documented in earlier air quality trends reports,[1-13] issued by EPA. The trend in O_3 is complicated by a major drop in measured concentration levels which occurred between 1978 and 1979, largely due to a change in the O_3 measurement calibration procedure.[14] Therefore, special attention is given to the period after 1978, because the change in the calibration procedure is not an influence during this time.

The 10-year trend (1977-1986) is complemented with a more recent 5-year trend (1982-1986). The 5-year trend increases the number of sites available for trend analysis. Emphasis is placed on the post-1981 period to take advantage of the larger number of sites and the fact that the data from this period should be of the highest quality, with sites meeting uniform siting criteria and high standards of quality assurance. Nationally, improvements can be seen for all the pollutants during the 5-year period.

The trends in ambient air quality, that follow, are presented as boxplots, which display the 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles of the data, as well as the composite average (Figure 1-2). The 5th, 10th and 25th percentiles depict the "cleaner" sites, while the 75th, 90th and 95th depict the "dirtier" sites and the median and average describe the "typical" sites. The use of the boxplots allow us to simultaneously compare trends in the "cleaner", "typical" and "dirtier" sites.

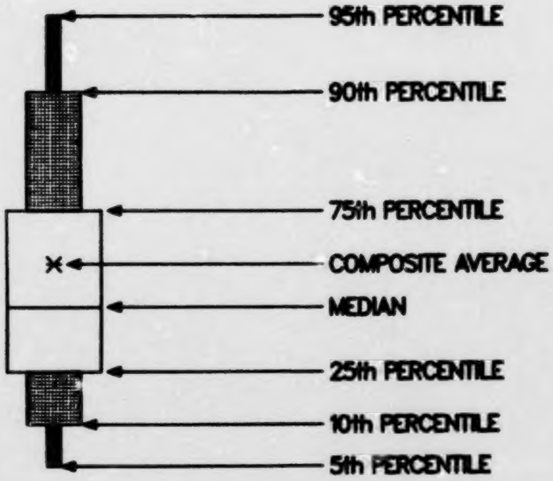

Figure 1-2. Illustrations of plotting conventions for boxplots.

All of the ambient air quality trend analyses are based on monitoring sites which recorded at least 8 of the 10 years of data in the period 1977 to 1986 or 4 out of 5 years in the period 1982 to 1986. Each year had to satisfy an annual data completeness criterion, which is discussed in Section 2.1, Data Base.

Finally, the Executive Summary also contains air quality maps of the United States to show at a glance how air quality varies among the 89 largest metropolitan statistical areas (MSA). In each map, a spike is plotted at the city location on the map surface. This represents the highest pollutant concentration, recorded in 1986, corresponding to the appropriate air quality standard. Each spike is projected onto a backdrop facilitating comparison with the level of the standard. This also provides an east-west profile of concentration variability throughout the country.

1.2 MAJOR FINDINGS

Total Suspended Particulate (TSP) - Annual average TSP levels, measured at 1435 sites, decreased 23 percent between 1977 and 1986 (Figure 1-3). This corresponds to a 25 percent decrease in estimated particulate emissions for the same period (Figure 1-4). TSP air quality levels generally do not improve in direct proportion to estimated emission reductions, however, because air quality levels are influenced by factors such as natural dust, reentrained street dust, construction activity, etc., which are not included in the emissions estimates. EPA has also found that the TSP data collected during the years 1979-1981 may be biased high due to the glass fiber filter used during these years, and that most of the large apparent 2-year decrease in pollutant concentrations between 1981 and 1982 can be attributed to a change in these filters.[11-13,15,16] For this reason, the portion of the Figure 1-3 graph corresponding to 1979-1981 is stippled, indicating the uncertainty associated with data from these intervening years. The more recent TSP data show a leveling off with a 3 percent decrease in ambient TSP levels and a 4 percent decrease in estimated emissions for the 1982-86 time period. Some minor year to year fluctuations may in part be attributable to year to year changes in meteorological conditions such as precipitation. The most recent 1986 annual geometric mean TSP concentration is plotted for the 89 largest MSAs (Figure 1-5). The highest concentrations are generally found in the industrial Midwest and arid areas of the West. The east-west profile shows that levels above the TSP standard of 75 ug/m^3 can be found throughout the Nation, but proportionally fewer MSAs exceed the standard in the East. On July 1, 1987, EPA promulgated new standards for particulate matter using a new indicator, PM_{10}, rather than TSP. This focuses on those particles with aerodynamic diameters smaller than 10 micrometers, which are likely to be responsible for adverse health effects because of their ability to reach the thoracic or lower regions of the respiratory tract. PM_{10} monitoring networks are now being deployed nationally. Future trends reports will present analyses based on the new particulate matter standards.

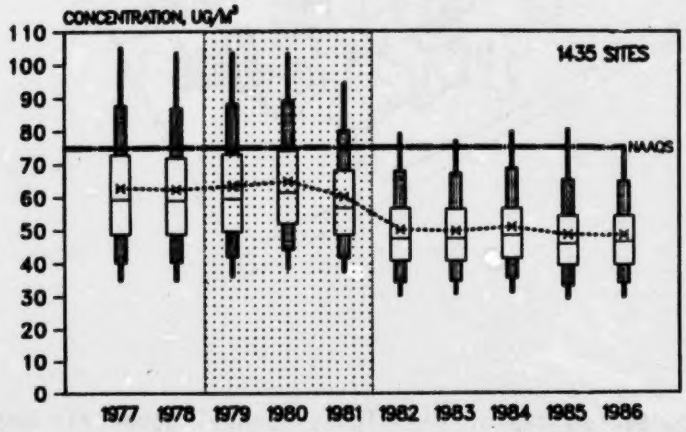

Figure 1-3. National boxplot trend in annual geometric mean TSP concentrations, 1977 - 1986.

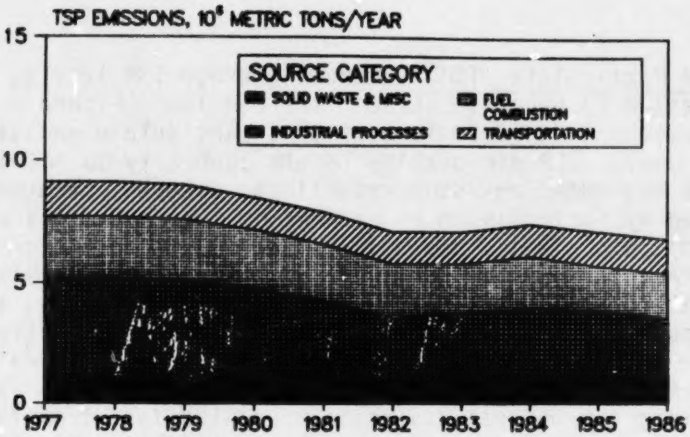

Figure 1-4. National trend in particulate emissions, 1977 - 1986.

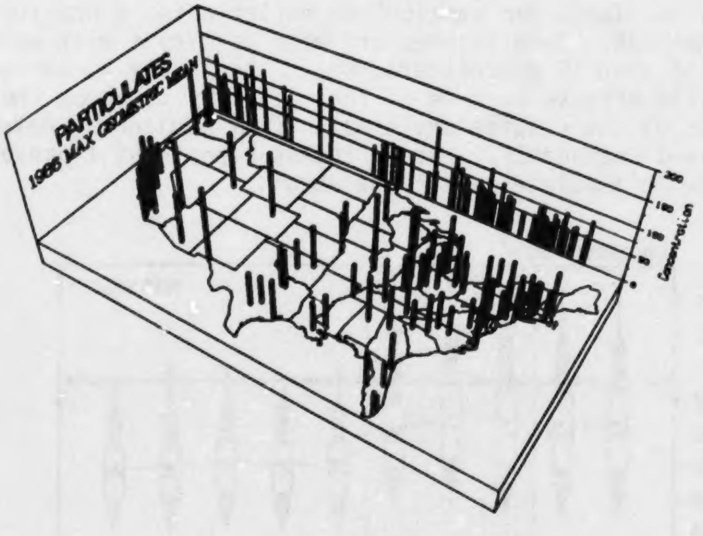
PARTICULATES
1986 MAX GEOMETRIC MEAN
200
150
100
50
0
Concentration

Figure 1-5. United States map of the highest annual geometric mean TSP concentration by MSA, 1986.

Sulfur Dioxide (SO_2) - Annual average SO_2 levels measured at 302 sites with continuous SO_2 monitors decreased 37 percent from 1977 to 1986 improving at a rate of approximately 4 percent per year (Figure 1-6). A comparable decrease of 43 percent was observed in the trend in the composite average of the second maximum 24-hour averages (Figure 1-7). An even greater improvement was observed in the estimated number of exceedances of the 24-hour standard, which decreased 98 percent (Figure 1-8). However, most of the exceedances as well as the bulk of the improvements occurred at source-oriented sites including a few smelter sites in particular. There was a 21 percent drop in sulfur oxide emissions during this 10-year period. (Figure 1-9). The difference between emissions and air quality trends can be attributed to several factors. SO_2 monitors with sufficient historical data for trends are mostly urban population-oriented and as such do not monitor many of the major emitters which tend to be located in more rural areas. The residential and commercial areas, where most monitors are located, have shown sulfur oxide emission decreases comparable to SO_2 air quality improvement. The most recent 1986 annual arithmetic mean SO_2 is plotted for the 89 largest MSAs (Figure 1-10). Among these large metropolitan areas, the higher concentrations are found in the heavily populated Midwest and Northeast. All urban areas have ambient air quality concentrations lower than the current annual standard of (.03 ppm) 80 ug/m^3. However, this map only represents areas with population greater than one half million; it does not reflect air quality in the vicinity of smelters or large power plants in rural areas, and it does not reflect violations of the 24-hour or 3-hour standards.

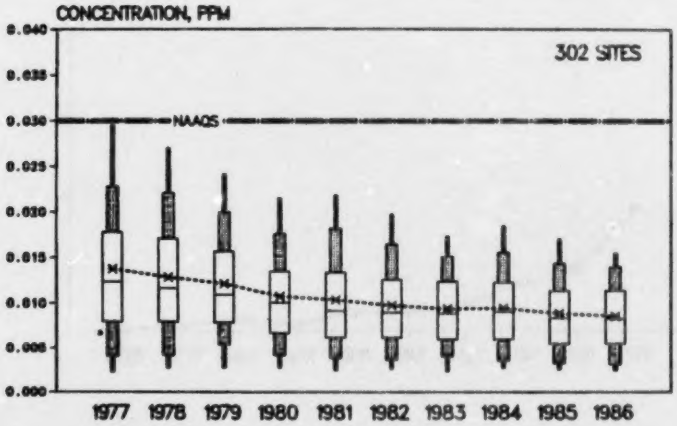

Figure 1-6. National boxplot trend in annual average SO_2 concentrations, 1977 - 1986.

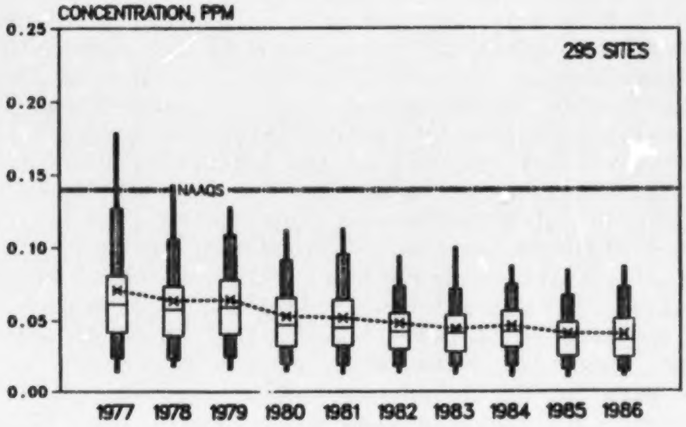

Figure 1-7. National boxplot trend in second highest 24-hour SO_2 concentrations, 1977 - 1986.

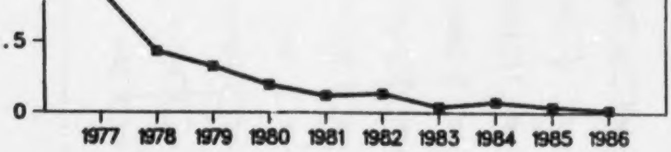

Figure 1-8. National trend in the composite average of the estimated number of exceedances of the 24-hour SO_2 NAAQS, 1977 - 1986.

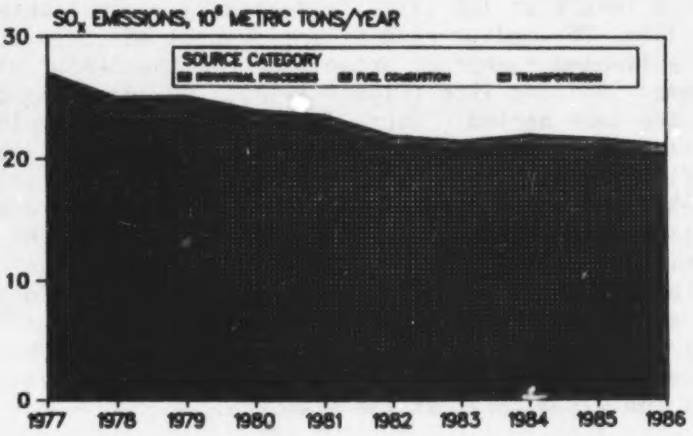

Figure 1-9. National trend in sulfur oxide emissions, 1977 - 1986.

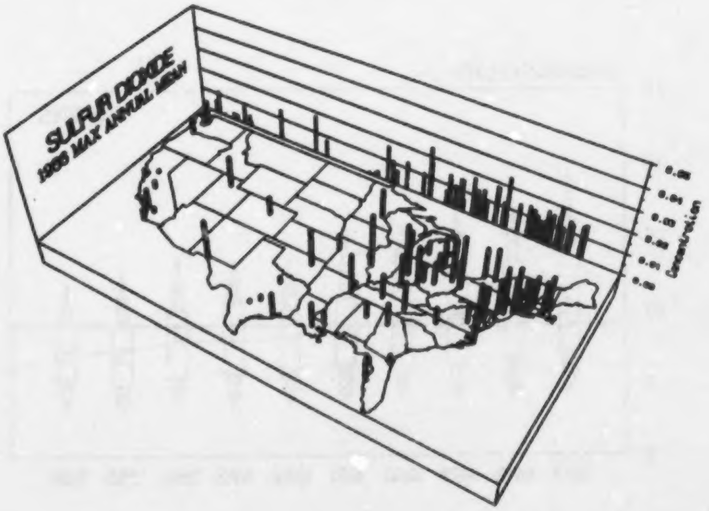
SULFUR DIOXIDE
1986 MAX ANNUAL MEAN
0.05
0.04
0.03
0.02
0.01
0.00
Concentration

Figure 1-10. United States map of the highest annual arithmetic mean SO_2 concentration by MSA, 1986.

Carbon Monoxide (CO) - Nationally, the second highest non-overlapping 8-hour average CO levels at 182 sites decreased 32 percent between 1977 and 1986 (Figure 1-11). The median rate of improvement has been about 4 percent per year. The estimated number of exceedances of the 8-hour NAAQS decreased 89 percent between 1977 and 1986 (Figure 1-12). CO emissions decreased 26 percent during the same period (Figure 1-13). Because CO monitors are typically located to identify potential problems, they are likely to be placed in traffic saturated areas that may not experience significant increases in vehicle miles of travel. As a result, the air quality levels at these locations generally improve at a rate faster than the nationwide reduction in emissions. The 1985 and 1986 levels are similar and indicate improvement relative to previous years. The most recent 1986 highest second maximum nonoverlapping 8-hour average CO concentration is plotted for the 89 largest MSAs (Figure 1-14). The east-west profile indicates that many of these urban areas in all geographic regions have air quality at or exceeding the 9 ppm level of the standard.

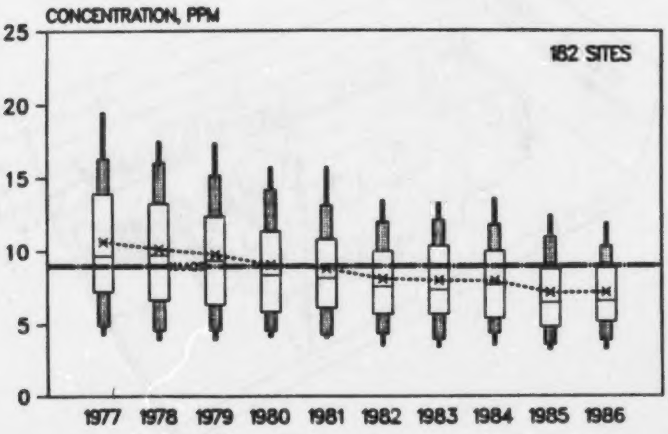

Figure 1-11. National boxplot trend in the second highest nonoverlapping 8-hour average CO concentrations, 1977 - 1986.

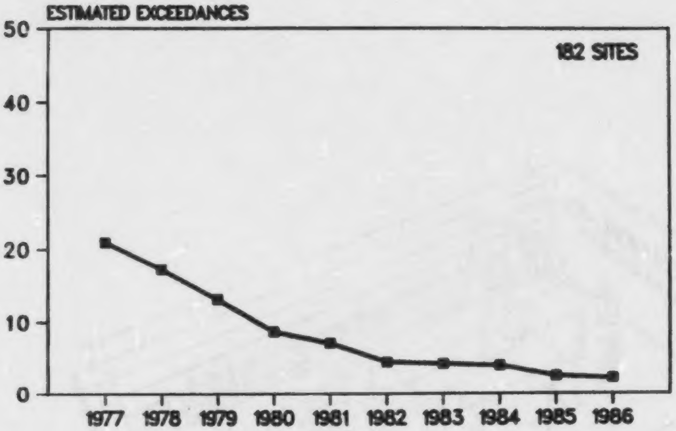

Figure 1-12. National trend in the composite average of the estimated number of exceedances of the 8-hour CO NAAQS, 1977 - 1986.

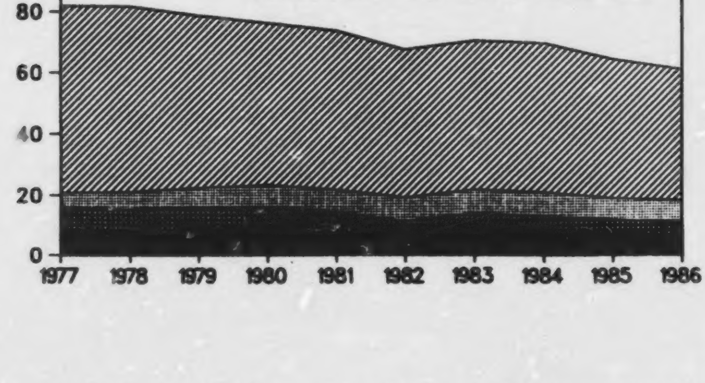

Figure 1-13. National trend in emissions of carbon monoxide, 1977 - 1986.

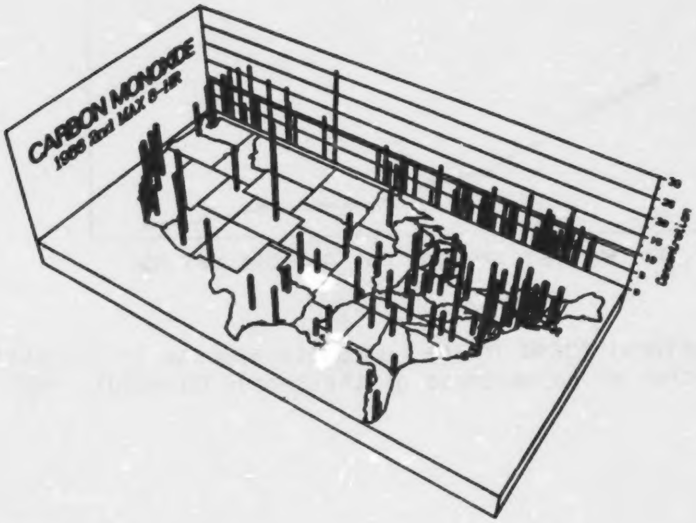
CARBON MONOXIDE
1986 2nd MAX 8-HR
0
5
10
15
20
25
30
Concentration

Figure 1-14. United States map of the highest second maximum nonoverlapping 8-hour average CO concentration by MSA, 1986.

Nitrogen Dioxide (NO_2) - Annual average NO_2 levels, averaged over 111 sites, increased from 1977 to 1979, and decreased through 1986, except for a slight increase in 1984 (Figure 1-15). The 1986 composite NO_2 average, however, is 14 percent lower than the 1977 level indicating a downward trend during the overall period. The trend in the estimated nationwide emissions of nitrogen oxides is similar to the NO_2 air quality trend. Between 1977 and 1986, total nitrogen oxide emissions decreased by 8 percent, and highway vehicle emissions, the source category likely impacting the majority of NO_2 monitoring sites, decreased by 13 percent (Figure 1-16). Between 1985 and 1986, the NO_2 composite average remained constant while the estimated emissions of nitrogen oxides decreased by 2 percent. This small year-to-year difference between the ambient levels and the emissions percent change is likely not significant given the relatively low ambient NO_2 levels. The most recent 1986 highest annual arithmetic mean NO_2 concentration is plotted for the 89 largest MSAs (Figure 1-17). Los Angeles, California is the only area in the country exceeding the air quality standard of .053 ppm.

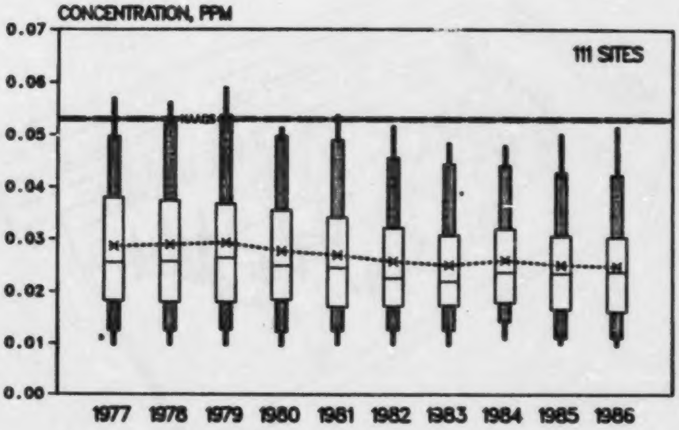

Figure 1-15. National boxplot trend in annual average NO_2 concentrations 1977 - 1986.

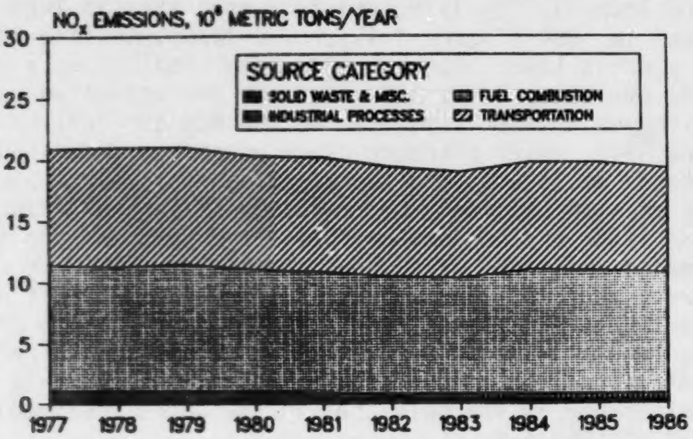

Figure 1-16. National trend in emissions of nitrogen oxides, 1977 - 1986.

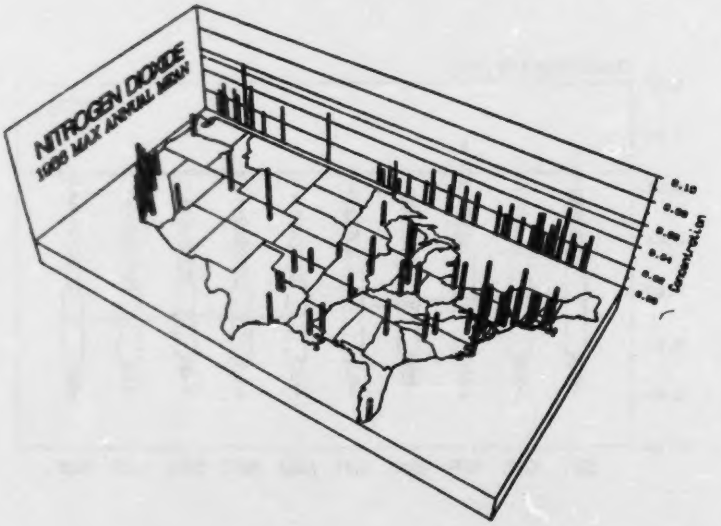
NITROGEN DIOXIDE
1986 MAX ANNUAL MEAN
0.10
0.08
0.06
0.04
0.02
0.00
Concentration

Figure 1-17. United States map of the highest annual arithmetic mean NO_2 concentration by MSA, 1986.

Ozone (O_3) - Nationally, the composite average of the second highest daily maximum 1-hour O_3 values, recorded at 242 sites, decreased 21 percent between 1977 and 1986 (Figure 1-18). However, this comparison is affected by a calibration change for ozone measurements that occurred in the 1978-79 time period. The stippled portion of Figures 1-18 and 1-20 indicate data affected by measurements taken prior to the calibration change. In the post-calibration period (1979-1986), O_3 levels decreased 13 percent (Figure 1-18). Volatile organic compound (VOC) emissions decreased 19 percent for the 1977-86 10-year period and 20 percent for the post-calibration 1979-86 period (Figure 1-19). The estimated number of exceedances of the ozone standard decreased 38 percent between 1979 and 1986 (Figure 1-20). The ozone trend in the post-calibration period shows 1979, 1980, and 1983 being higher than the other years. The possible contribution of meteorological conditions to the higher 1983 levels has been discussed in previous reports.[11-13] The most recent 1986 highest second daily maximum 1-hour average O_3 concentration is plotted for the 89 largest MSAs (Figure 1-21). Many of these areas did not meet the 0.12 ppm standard in 1986. The highest concentrations are observed in Southern California, but high levels also persist in the Texas Gulf Coast, Northeast corridor, and other heavily populated regions.

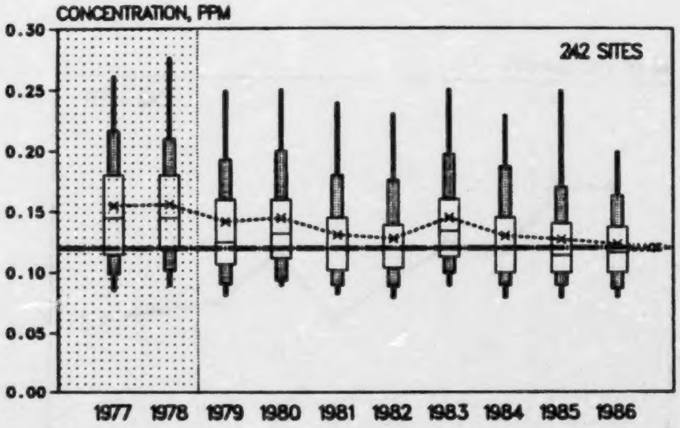

Figure 1-18. National boxplot trend in the second highest daily maximum 1-hour O_3 concentrations, 1977 - 1986.

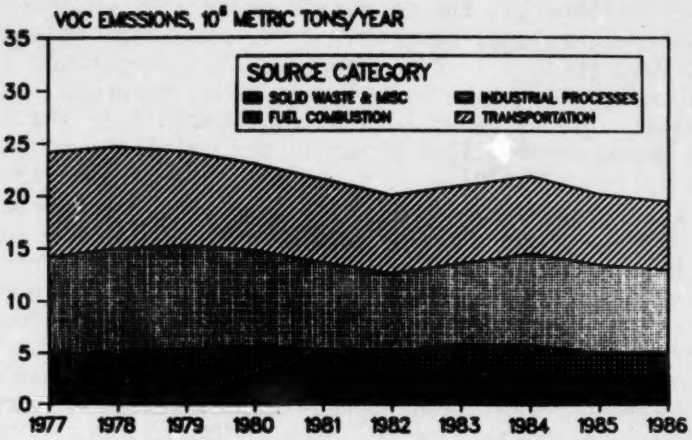

Figure 1-19. National trend in emissions of volatile organic compounds, 1977 - 1986.

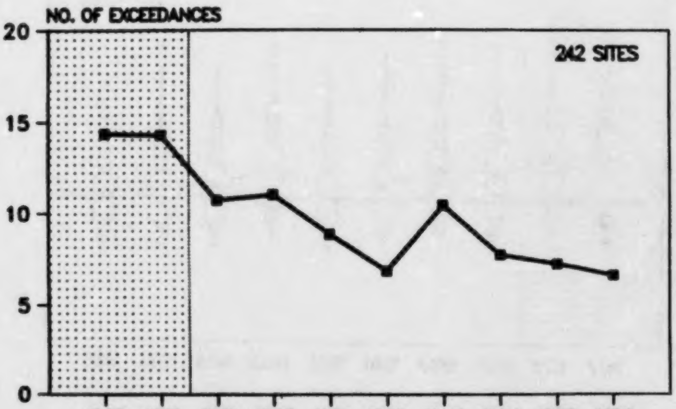

Figure 1-20. National trend in the composite average of the number of daily exceedances of the O_3 NAAQS in the O_3 season, 1977 - 1986.

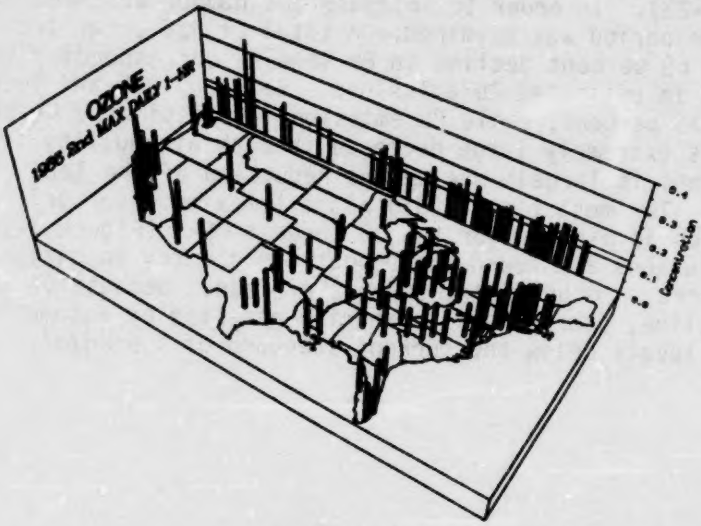
OZONE
1986 2nd MAX DAILY 1-HR
0.4
0.3
0.2
0.1
0.0
Concentration

Figure 1-21. United States map of the highest second daily maximum 1-hour average O_3 concentration by MSA, 1986.

Lead (Pb) - The composite maximum quarterly average of ambient Pb levels, recorded at 82 urban sites, decreased 87 percent between 1977 and 1986 (Figure 1-22). Lead emissions declined 94 percent during the same period (Figure 1-23). In order to increase the number of trend sites, the 1982 to 1986 time period was examined. A total of 326 urban trend sites (1982 to 1986) measured a 68 percent decline in Pb levels, corresponding to a 84 percent decrease in estimated Pb emissions. Between 1985 and 1986 ambient Pb levels declined 35 percent, while Pb emissions are estimated to have declined 59 percent. This extremely large decrease in both air quality levels and estimated emissions is largely due to the reduction of the lead content of leaded gasoline. The most recent 1986 highest maximum quarterly average lead concentration is plotted for the 89 largest MSAs (Figure 1-24). The highest concentrations are found throughout the country in cities containing nonferrous smelters or other point sources of lead. Because of the switch to unleaded gasoline, other areas, primarily affected by automotive lead emissions, show levels below the current standard of 1.5 ug/m^3.

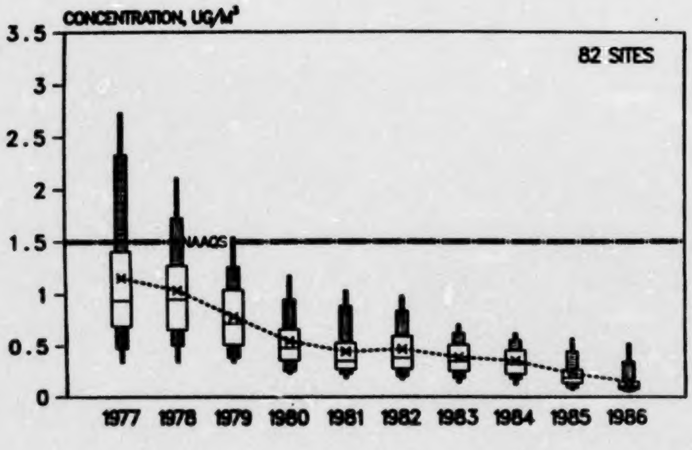

Figure 1-22. National boxplot trend in maximum quarterly average Pb concentrations, 1977 - 1986.

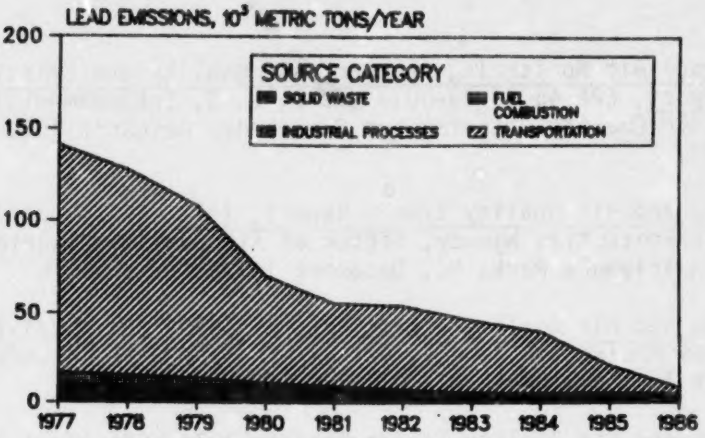

Figure 1-23. National trend in lead emissions, 1977 - 1986.

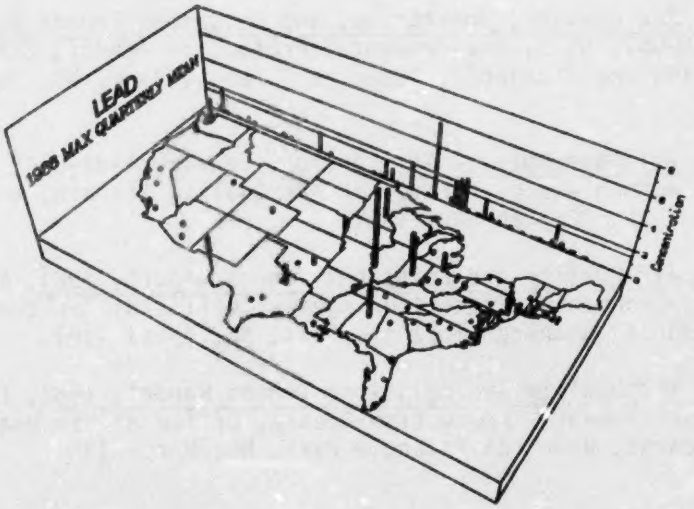
LEAD
1986 MAX QUARTERLY MEAN
Concentration

Figure 1-24. United States map of the highest maximum quarterly average lead concentration by MSA, 1986.

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14. *Measurement of Ozone in the Atmosphere*, 43 FR 26971, June 22, 1978.

15. Written communication from Thomas R. Hauser, Environmental Monitoring Systems Laboratory, U. S. Environmental Protection Agency, Research Triangle Park, NC, to Richard G. Rhoads, Monitoring and Data Analysis Division, U. S. Environmental Protection Agency, Research Triangle Park, NC, January 11, 1984.

16. N. H. Frank, "Nationwide Trends in Total Suspended Particulate Matter and Associated Changes in the Measurement Process", presented at the Air Pollution Control Association, American Society For Quality Control Specialty Conference on Quality Assurance in Air Pollution Measurement, Boulder, CO, October 1984.

2. INTRODUCTION

This report focuses on both 10-year (1977-1986) and 5-year (1982-1986) national air quality trends in each of the major pollutants for which National Ambient Air Quality Standards have been established, as well as Regional and, where appropriate, short-term air quality trends. The national analyses are complemented in Section 5 with air quality trends in selected urbanized areas for the period 1982 through 1986. In both the national 5-year trend and the urbanized area trends, the shorter time period was used to expand the number of sites available for trend analysis. The areas that were examined are: Atlanta, GA; Baltimore, MD; Boston, MA; Chicago, IL-Northwestern IN; Denver, CO; Detroit, MI; Houston, TX; Los Angeles-Long Beach, CA; New York, NY-Northeastern NJ; Philadelphia, PA-NJ; Phoenix, AZ; Portland, OR-WA; St. Louis, MO-IL, and Seattle, WA.

The national air quality trends are presented for all sites and the National Air Monitoring Station (NAMS) sites. The NAMS were established through monitoring regulations promulgated in May 1979[1] to provide accurate and timely data to the U. S. Environmental Protection Agency (EPA) from a national air monitoring network. The NAMS are located in areas with high pollutant concentrations and high population exposure. These stations meet uniform criteria for siting, quality assurance, equivalent analytical methodology, sampling intervals, and instrument selection to assure consistent data reporting among the States. Other sites operated by the State and local air pollution control agencies, such as the State and Local Air Monitoring Stations (SLAMS) and Special Purpose Monitors (SPM), in general, also meet the same rigid criteria, except that in addition to being located in the area of highest concentration and high population exposure, they are located in other areas as well. The ambient levels presented are the results of direct air pollution measurements.

In addition to ambient air quality, trends are also presented for annual nationwide emissions. These are estimates of the amount and kinds of pollution being emitted by automobiles, factories, and other sources, based upon the best available engineering calculations for a given time period. The emission trends are taken from the EPA publication, National Air Pollutant Emission Estimates, 1940-1986[2] and the reader is referred to this publication for more detailed information. Except for lead emissions, which are reported in gigagrams (one thousand metric tons), the emission data are reported as teragrams (one million metric tons) emitted to the atmosphere per year.[2]

Air quality status may be measured by comparing the ambient air pollution levels with the appropriate primary and secondary National

Ambient Air Quality Standards (NAAQS) for each of the pollutants (Table 2-1). Primary standards protect the public health; secondary standards protect the public welfare as measured by effects of pollution on vegetation, materials, and visibility. The standards are further categorized for different averaging times. Long-term standards specify an annual or quarterly mean that may not be exceeded; short-term standards specify upper limit values for 1-, 3-, 8-, or 24-hour averages. With the exception of the pollutants ozone and PM_{10}, the short-term standards are not to be exceeded more than once per year. The ozone standard requires that the expected number of days per calendar year with daily maximum hourly concentrations exceeding 0.12 parts per million (ppm) be less than or equal to one. The new 24-hour PM_{10} standard also allows one expected exceedance per year.

Section 4 of this report, "Air Quality Levels in Metropolitan Statistical Areas (MSAs)," provides interested members of the air pollution control community, the private sector and the general public with greatly simplified air pollution information. Air quality statistics for the years 1984, 1985 and 1986 are presented for each of the pollutants for all MSA's with populations exceeding 500,000.

2.1 DATA BASE

The ambient air quality data used in this report were obtained from EPA's National Aerometric Data Bank (NADB). Air quality data are submitted to the NADB by both State and local governments, as well as federal agencies. At the present time, there are over 250 million air pollution measurements on the NADB, the vast majority of which represent the more heavily populated urban areas of the Nation.

As in last year's report[3], the size of the available air quality trends data base has been expanded by merging data at sites which have experienced changes in the agency operating the site, the instrument used, or a change in the project code, such as a change from population oriented to special purpose monitoring.

In order for a monitoring site to have been included in the national 10-year trend analysis, the site had to contain at least 8 out of the 10 years of data in the period 1977 to 1986. For the national 5-year trend and urban area analyses, the site had to contain 4 out of 5 years of data to be included as a trend site. Each year with data had to satisfy an annual data completeness criterion. The air quality data are divided into two major groupings -- 24-hour measurements and continuous 1-hour measurements. The 24-hour measurements are obtained from monitoring instruments that produce one measurement per 24-hour period and are typically operated on a systematic sampling schedule of once every 6 days or 61 samples per year. Such instruments are used to measure TSP, SO_2, NO_2, and Pb. For these measurement methods, the NADB defines a

TABLE 2-1. National Ambient Air Quality Standards (NAAQS) in Effect in 1986

POLLUTANT	PRIMARY (HEALTH RELATED)		SECONDARY (WELFARE RELATED)	
	AVERAGING TIME	STANDARD LEVEL CONCENTRATION[a]	AVERAGING TIME	CONCENTRATION
TSP[b]	Annual Geometric Mean	75 ug/m^3		
	24-hour	260 ug/m^3	24-hour	150 ug/m^3
SO_2	Annual Arithmetic Mean	(0.03 ppm) 80 ug/m^3	3-hour	1300 ug/m^3 (0.50 ppm)
	24-hour	(0.14 ppm) 365 ug/m^3		
CO	8-hour	9 ppm (10 mg/m^3)	No Secondary Standard	
	1-hour	35 ppm (40 mg/m^3)	No Secondary Standard	
NO_2	Annual Arithmetic Mean	0.053 ppm (100 ug/m^3)	Same as Primary	
O_3	Maximum Daily 1-hour Average	0.12 ppm[c] (235 ug/m^3)	Same as Primary	
Pb	Maximum Quarterly Average	1.5 ug/m^3	Same as Primary	

[a] Parenthetical value is an approximately equivalent concentration.

[b] TSP was the indicator pollutant for the original particulate matter (PM) standards. New PM standards were promulgated in 1987, using PM_{10} (particles less than 10u in diameter) as the indicator pollutant. The levels and averaging times for these new primary standards are 50 ug/m^3 for the annual mean and 150 ug/m^3 for the 24-hour average. Adjustments are made for incomplete data. The secondary standards are the same as the primary.

[c] The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1, as determined in accordance with Appendix H of the Ozone NAAQS.

valid quarter's record as one consisting of at least five sample measurements representively distributed among the months of that quarter. Distributions of measurements that show no samples in 2 months of a quarter or that show no samples in 1 month and only one sample in another month are judged unacceptable for calculating a representative estimate of the mean. A valid annual mean for TSP, SO_2 and NO_2, measured with this type of sampler, requires four valid quarters to satisfy the NADB criteria. For the pollutant lead, the data used have to satisfy the criteria for a valid quarter in at least 3 of the 4 possible quarters in a year for the national trend.

The 1-hour data are obtained from monitoring instruments that operate continuously, producing a measurement every hour for a possible total of 8760 hourly measurements in a year. For continuous hourly data, a valid annual mean for SO_2 and NO_2 requires at least 4380 hourly observations. This same annual data completeness of at least 4380 hourly values was required for the CO standard related statistics - the second maximum nonoverlapping 8-hour average and the estimated number of exceedances of the 8-hour average CO standard.

A slightly different criterion was used for the SO_2 standard related daily statistics - the second daily maximum 24-hour average and the estimated number of daily exceedances of the SO_2 standard. Instead of requiring 4380 or more hourly values, 183 or more daily values were required. A valid day is defined as one consisting of at least 18 hourly observations. This minor modification in the criterion resulted in a 2 percent difference in the total number of SO_2 trend sites for the 10 year trend evaluation of the annual arithmetic mean, 302 sites, as opposed to 295 trend sites for the evaluation of both the second maximum daily average and the estimated number of standard exceedances. The difference in the number of SO_2 trend sites for the 5-year trend period is 583 sites selected for evaluating the annual mean versus 585 sites selected for evaluating the second maximum daily average and the estimated number of exceedances.

Finally, because of the seasonal nature of ozone, both the second daily maximum 1-hour value and the estimated number of exceedances of the O_3 NAAQS were calculated for the ozone season, which varies by State.[4] For example, in California the ozone season is defined as 12 months, January through December, while in New Jersey it is defined as 7 months, April through October. In order for a site to be included it had to have at least 50 percent of the daily data in the ozone season.

For all the pollutants, the site must satisfy the annual completeness criterion, specified above, in at least 8 out of 10 years to be included in the 10-year air quality trends data base and 4 out of 5 years in both the 5-year trend and urbanized area trend data bases. The shorter time period was used in the urbanized area analyses to expand the number of sites available for trend analyses (Table 2-2).

In calculating the national and urban area trend analyses, each site was weighted equally. The report examines both 10-year (1977 to 1986) and 5-year (1982 to 1986) trends. The use of moving 10-year and 5-year windows for trends yields a data base that is more consistent with the current monitoring network. In addition, this procedure increased the total number of trend sites by 8 percent for the 10-year period and 2 percent for the 5-year period as compared to the data bases used in the last annual report. The 5-year trend period is introduced to increase the number of trend sites available for analysis (Table 2-2). The trend from 1982 on reflects the period following the implementation of the monitoring regulations.[1] The regulations required uniform siting of monitors and placed greater emphasis on quality assurance. In general, the data from the post 1982 period should be of the highest quality. As would be expected, there are considerably more trend sites for the 5-year period than the 10-year period - 4083 total trend sites versus 2354 trends sites, respectively (Table 2-2). This 73 percent increase in the number of trends sites for the 5-year period over the 10-year period reflects the greater utilization of the ambient air quality data that is achieved by examining the shorter time period. Trend sites can be found in all EPA Regions (Figure 2-1) for TSP, SO_2, CO, NO_2 and O_3 and lead for the 5-year period.

2.2 TREND STATISTICS

The air quality analyses presented in this report comply with the recommendations of the Intra-Agency Task Force on Air Quality Indicators.[5] This task force was established in January 1980 to recommend standardized air quality indicators and statistical methodologies for presenting air quality status and trends. The Task Force report was published in February 1981. The air quality statistics used in these pollutant-specific trend analyses relate to the appropriate NAAQS's. Two types of standard-related statistics are used - peak statistics (the second maximum 24-hour SO_2 average, the second maximum nonoverlapping 8-hour CO average, and the second daily maximum 1-hour O_3 average) and long-term averages (the annual geometric mean for TSP, the annual arithmetic means for SO_2 and NO_2, and the quarterly arithmetic mean for lead). In the case of the peak statistics, the second maximum value is used, because this is the value which traditionally has been used to determine whether or not a site has or has not violated an air quality standard in a particular year, and, therefore, the second maximum value is of significant importance. A composite average of each of these statistics is used, by averaging each statistic over all available trend sites, in the graphical presentations which follow.

In addition to the standard related statistics, other statistics are used, when appropriate, to further clarify observed air quality trends. Particular attention is given to the estimated number of exceedances of the short-term NAAQS's. The estimated number of exceedances is the measured number of exceedances adjusted to account for incomplete sampling.

For a pollutant such as ozone, for which the level of the standard was revised during the 1977-1986 time period, exceedances for all years were computed using the most recent level of the standard. This was done to ensure that the trend in exceedances is indicative of air quality trends rather than a change in the level of the standard.

TABLE 2-2. Comparison of Number of Sites for 10-Year and 5-Year Air Quality Trends

POLLUTANT	NUMBER OF SITES 1977-86 TREND	1982-86 TREND	% CHANGE IN THE NUMBER OF TREND SITES 1977-86 vs. 1982-86
Total Suspended Particulate (TSP)	1435	2044	+42%
Sulfur Dioxide (SO_2)	302	583	+93%
Carbon Monoxide (CO)	182	363	+99%
Ozone (O_3)	242	539	+123%
Nitrogen Dioxide (NO_2)	111	228	+105%
Lead (Pb)	82	326	+298%
Total	2354	4083	+73%

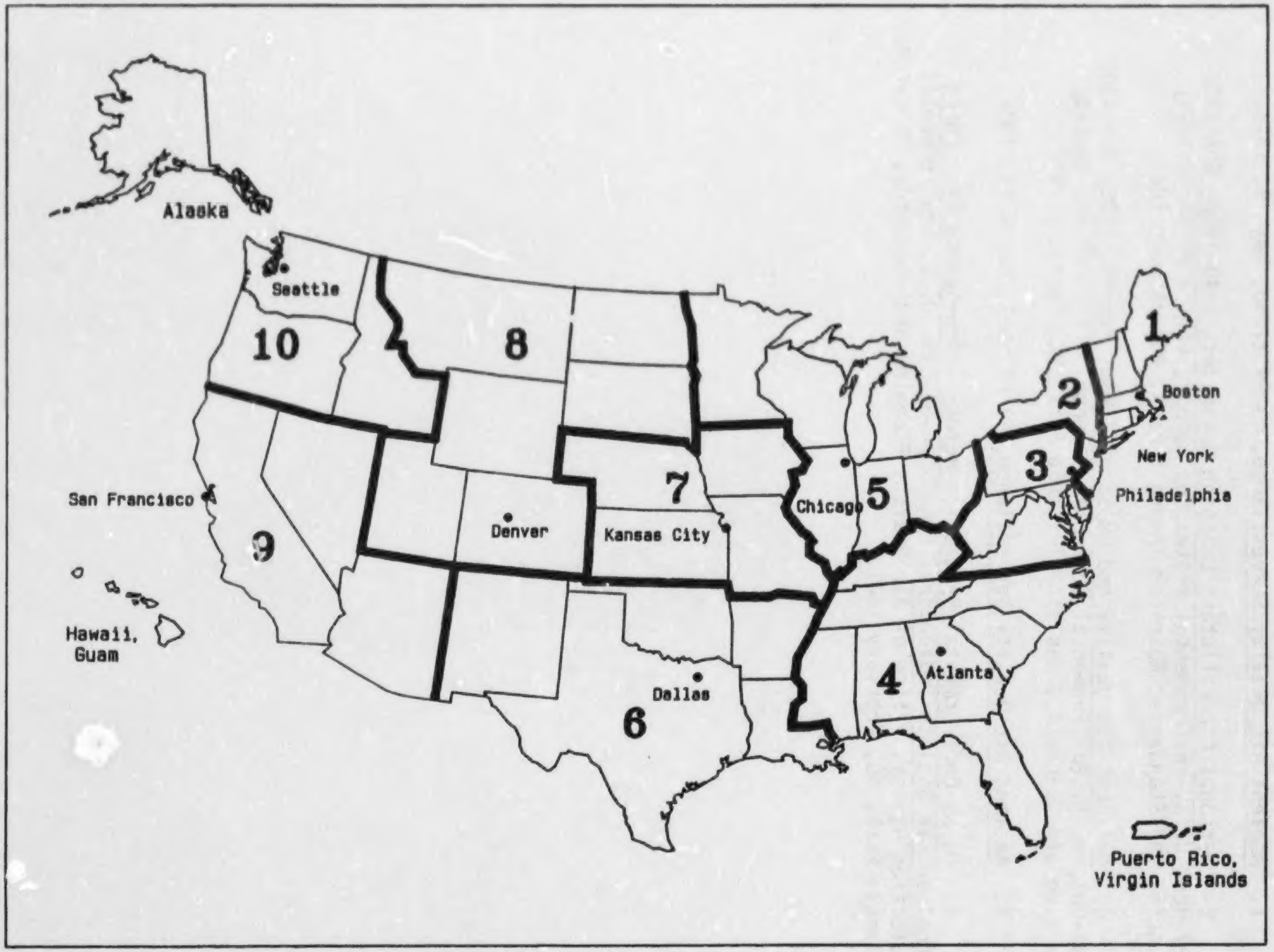
Alaska
Seattle
10
8
1
2
Boston
3
New York
Philadelphia
7
5
Chicago
San Francisco
9
Denver
Kansas City
Hawaii,
Guam
4
Atlanta
Dallas
6
Puerto Rico,
Virgin Islands

Figure 2-1. Ten Regions of the U.S. Environmental Protection Agency.

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5. U. S. Environmental Protection Agency Intra-Agency Task Force Report on Air Quality Indicators, EPA-450/4-81-015, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, February 1981.

3. NATIONAL AND REGIONAL TRENDS IN NAAQS POLLUTANTS

This chapter focuses on both 10-year (1977-1986) and more recent 5-year (1982-1986) trends in each of the six major pollutants, as well as short term air quality trends. Comparisons are made between all the trend sites and the subset of NAMS. Trends are examined for both the Nation and the ten EPA Regions. The air quality trends data base has been expanded for all pollutants by merging data at sites which have experienced changes in the agency operating the site, the instrument used, or the designation of the project code, such as residential to commercial.

The air quality trends information is presented using trend lines, confidence intervals, boxplots[1] and bar graphs. This report presents statistical confidence intervals to facilitate a better understanding of measured changes in air quality. Confidence intervals are placed around composite averages, which are based on sites that satisfy annual data completeness requirements. The confidence intervals can be used to make comparisons between years; if the confidence intervals for any 2 years do not overlap, then the composite averages of the 2 years are significantly different (Figure 3-1). Ninety-five percent confidence intervals for composite averages of annual means (arithmetic and geometric) and second maxima were calculated from a two-way analysis of variance followed by an application of the Tukey Studentized Range.[2] The confidence intervals for composite averages of estimated exceedances were calculated by fitting Poisson distributions[3] to the exceedances each year and then applying the Bonferroni multiple comparisons procedure.[4] The utilization of these procedures is explained in publications by Pollack, Hunt and Curran[5] and Pollack and Hunt.[6]

The boxplots have the advantage of displaying, simultaneously, several features of the data. Figure 3-2 illustrates the use of this technique in presenting the 5th, 10th, 25th, 50th (median), 75th, 90th and 95th percentiles of the data, as well as the composite average. The 5th, 10th and 25th percentiles depict the "cleaner" sites. The 75th, 90th and 95th depict the "dirtier" sites, and the median and average describe the "typical" sites. For example, 90 percent of the sites would have concentrations lower than the 90th percentile. Although the average and median both characterize typical behavior, the median has the advantage of not being affected by a few extremely high observations. The use of the boxplots allows us to simultaneously compare trends in the "cleaner", "typical" and "dirtier" sites.

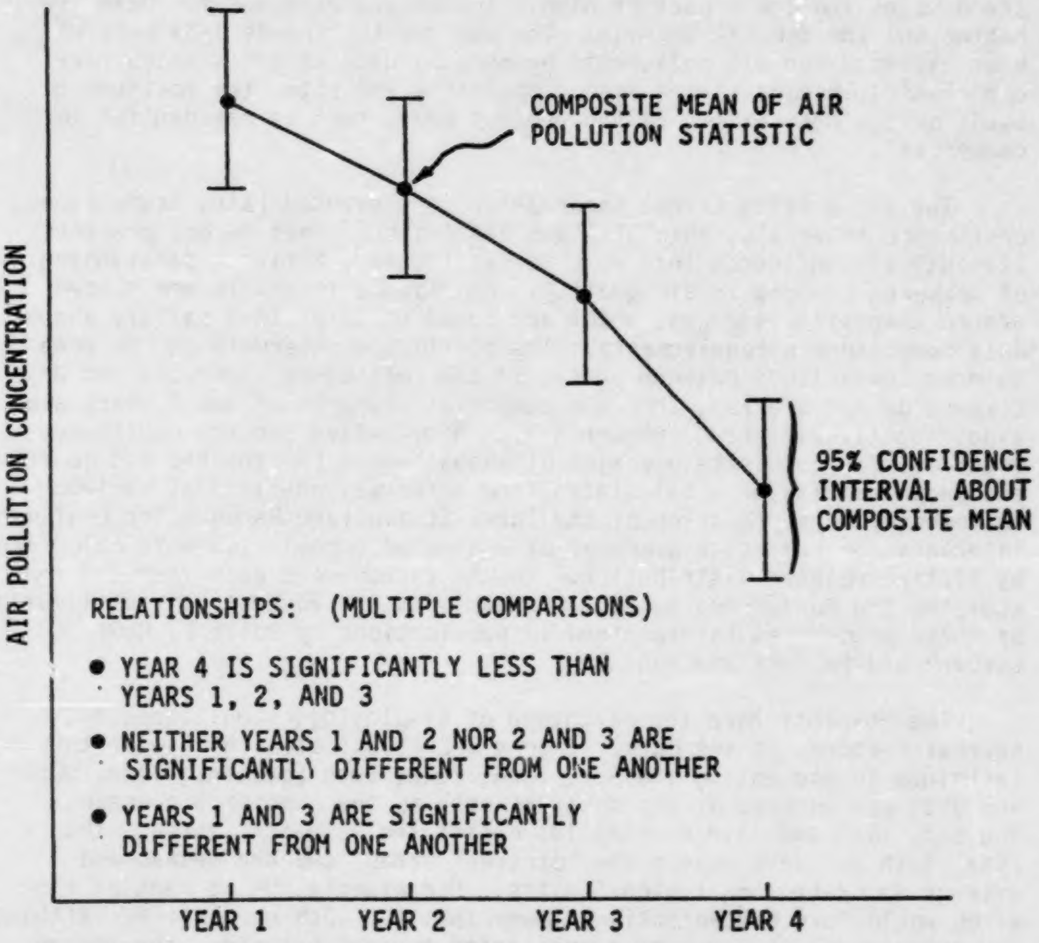

Figure 3-1. Sample illustration of use of confidence intervals to determine statistically significant change.

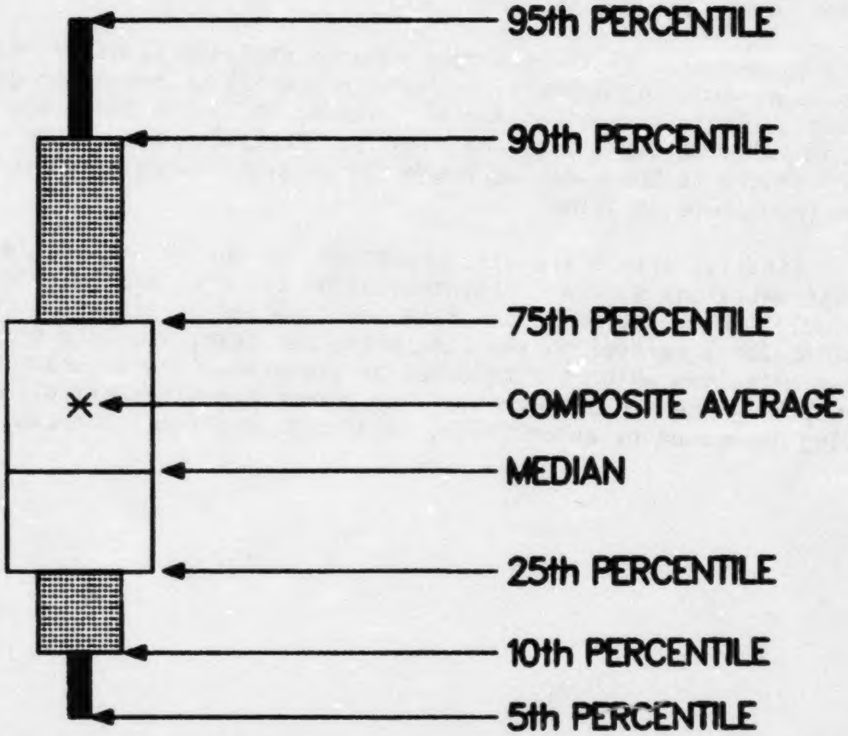
95th PERCENTILE
90th PERCENTILE
75th PERCENTILE
COMPOSITE AVERAGE
MEDIAN
25th PERCENTILE
10th PERCENTILE
5th PERCENTILE

Figure 3-2. Illustration of plotting conventions for boxplots.

Boxplots of all trend sites are presented for each year in the 10-year trend. In the recent 5-year trend, the boxplots are presented for the years 1982 through 1986. The recent 5-year trend was introduced in the 1984 report[7] to increase the number of sites available for analysis. Emphasis is placed on the recent 5-year period to take advantage of the larger number of sites and the fact that the data from this period should be of the highest quality, with sites meeting uniform siting criteria and high standards of quality assurance.

Bar graphs are used for the Regional comparisons with the 5-year trend data base. The composite averages of the appropriate air quality statistic of the years 1984, 1985 and 1986 are presented. The approach is simple and it allows the reader at a glance to compare the short-term trend in all ten EPA Regions.

In addition to the standard related statistics, other statistics are used, when appropriate, to further clarify observed air quality trends. Particular attention is given to the estimated number of exceedances of the short-term NAAQS's. The estimated number of exceedances is the measured number of exceedances adjusted to account for incomplete sampling.

Finally, trends are also presented for annual nationwide emissions. These emissions data are estimated using the best available engineering calculations. The emissions data are reported as teragrams (one million metric tons) emitted to the atmosphere per year, with the exception of lead emissions which are reported as gigagrams (one thousand metric tons).[8] These are estimates of the amount and kinds of pollution being generated by automobiles, factories, and other sources.

3.1 TRENDS IN TOTAL SUSPENDED PARTICULATE

Air pollutants called particulate matter include dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires and natural windblown dust as well as particles formed in the atmosphere by transformation of emitted gases such as sulfur dioxide and volatile organic compounds.

Total suspended particulate (TSP) is one indicator of suspended particles in the ambient air. TSP is measured using a high volume sampler (Hi-Vol) which collects suspended particles ranging up to approximately 45 micrometers in diameter. Annual and 24-hour National Ambient Air Quality Standards (NAAQS) for particulate matter were set in 1971 using TSP as the indicator pollutant.

On July 1, 1987, EPA promulgated new annual and 24-hour standards for particulate matter using a new indicator, PM_{10}, that includes only those particles with aerodynamic diameter smaller than 10 micrometers. These smaller particles are likely to be responsible for most of the adverse health effects because of their ability to reach the thoracic or lower regions of the respiratory tract. The original (TSP) standards were an annual geometric mean of 75 ug/m^3, not to be exceeded, and a 24-hour concentration of 260 ug/m^3, not to be exceeded more than once per year. The new (PM_{10}) standards specify an expected annual arithmetic mean not to exceed 50 ug/m^3 and an expected number of 24-hour concentrations greater than 150 ug/m^3 per year not to exceed one. Because the original standards were applicable through 1986, the particulate matter trends presented in this section will be based on TSP. The annual geometric mean for TSP is a more stable indicator of air quality than the observed 24-hour peak values, and will be used as the trend statistic.

Now that the standards have been revised, PM_{10} monitoring networks are being deployed nationally. When sufficient information is available, future trends reports will present analyses based on the new particulate matter indicator.

3.1.1 Long-term TSP Trends: 1977-86

The 10-year trend in average TSP levels, 1977 to 1986, is shown in Figure 3-3 for 1435 sites geographically distributed throughout the Nation and for the subset of 375 National Air Monitoring Stations (NAMS) which are located in the large urban areas. The TSP levels are expressed in terms of the composite average annual geometric mean.

The curves shown in Figure 3-3 indicate a very slight decrease in composite levels from 1977-1981, followed by a sizeable decrease between 1981 and 1982 and relatively stable levels between 1982 and 1986. The NAMS sites show higher composite levels than the sites for the Nation in general, but appear to show a similar pattern. Both curves display their lowest values in 1986.

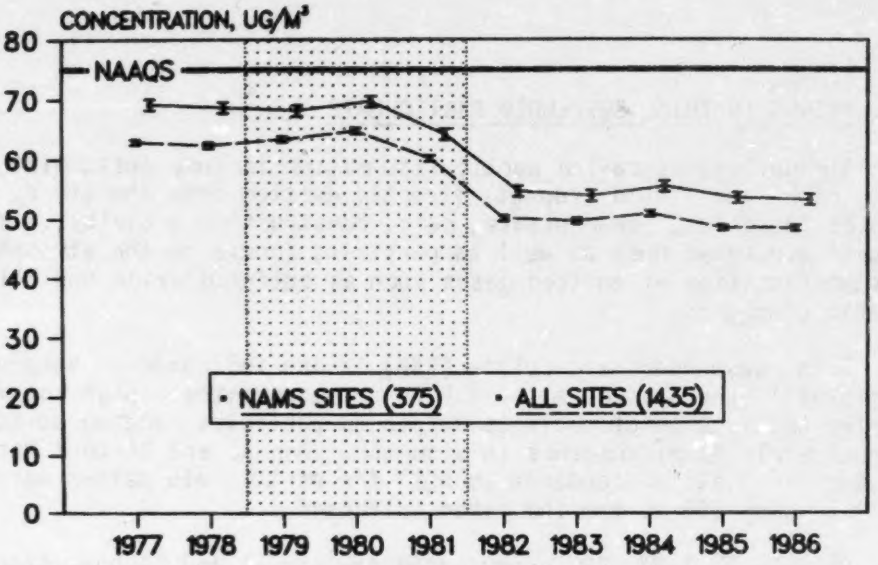

Figure 3-3. National trend in the composite average of the geometric mean total suspended particulate at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

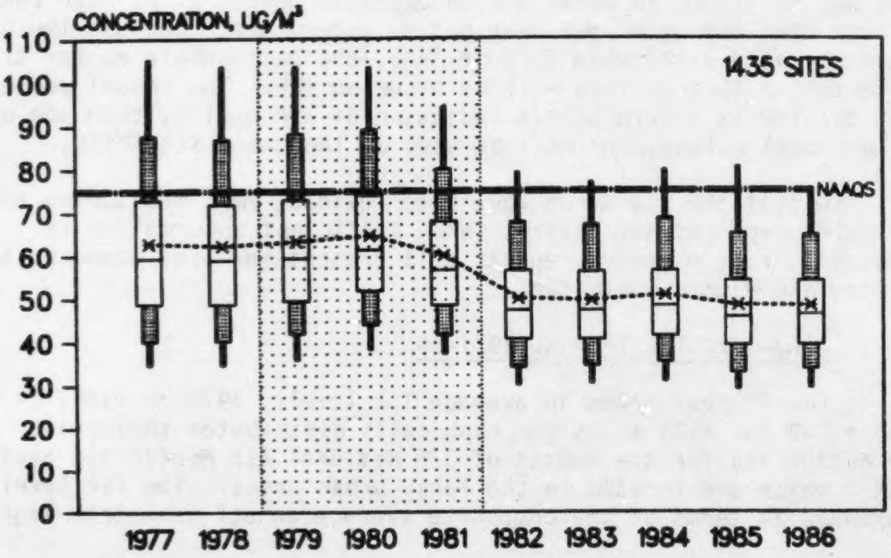

Figure 3-4. Boxplot comparisons of trends in annual geometric mean total suspended particulate concentrations at 1435 sites, 1977-1986.

The composite average of TSP levels measured at 1435 sites, distributed throughout the Nation, decreased 23 percent during the 1977 to 1986 time period and the subset of 375 NAMS also decreased 23 percent. From the curves in Figure 3-3, it appears that most of this decrease occurred between the measured levels of 1981 and 1982. EPA has found, however, that the TSP data collected during the years 1979-1981 may be biased high due to the glass fiber filter used during these years, and that most of the large apparent decrease in pollutant concentrations between 1981 and 1982 can be attributed to a change in these filters.[9-12] For this reason, the portion of the Figure 3-3 graph corresponding to 1979-1981 is stippled, indicating the uncertainty associated with these data. Due to the change in TSP filters, the pattern of the yearly change in TSP between 1978 and 1982 is difficult to assess.

Figures 3-3 and 3-4 present two different displays of the air quality trend at the 1435 TSP sites, nationally, over the 1977-1986 time period. With 95 percent confidence intervals developed for the composite annual estimates (Figure 3-3), it can be seen that the 1986 as well as the 1982 to 1985 levels are all significantly lower than those of 1977. Also, 1985 and 1986 are statistically indistinguishable, but are both significantly lower than the 1982 to 1984 levels. This difference is discussed in more detail in Section 3.1.2. In Figure 3-4, boxplots present the entire national concentration distribution by year and show that a decrease occurred in every percentile level between 1977 and 1986.

Nationwide TSP emission trends show an overall decrease of 25 percent from 1977 to 1986 which coincidentally matches the TSP air quality improvement. (See Table 3-1 and Figure 3-5). The trend in PM emissions is normally not expected to agree with the trend in ambient TSP levels due to unaccounted for natural PM background and uninventoried emission sources such as reentrained dust. The reduction in particulate emissions occurred primarily because of the reductions in industrial processes. This is attributed to installation of control equipment, and also reduced activity in some industries, such as iron and steel. Other areas of TSP emission reductions include reduced coal burning by non-utility users and installation of control equipment by electric utilities that burn coal.[8]

3.1.2 Recent TSP Trends: 1982-86

Figure 3-6 presents a boxplot display of the 1982-1986 TSP data base which represents 2044 monitoring sites. A small 3 percent decrease is evident in composite average levels between 1982 and 1986. It can also be seen that, nationally, TSP levels in 1984 were the highest in the 5-year period, while 1986 was the lowest. This pattern in air quality generally matches the 5-year trend in national particulate emission estimates. Emissions decreased 4 percent from 1982 to 1986, were highest in 1984 and achieved a new low in 1986.

Table 3-1. National Particulate Emission Estimates, 1977-1986.

(million metric tons/year)

Source Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Transportation	1.4	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.4	1.4
Fuel Combustion	2.5	2.5	2.5	2.4	2.3	2.2	2.0	2.1	1.8	1.8
Industrial Processes	4.0	4.0	3.8	3.3	3.0	2.6	2.4	2.8	2.8	2.5
Solid Waste	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Miscellaneous	0.8	0.8	0.9	1.1	0.9	0.7	1.1	0.9	0.8	0.8
Total	9.1	9.1	8.9	8.5	8.0	7.1	7.1	7.4	7.0	6.8

NOTE: The sum of sub-categories may not equal total due to rounding.

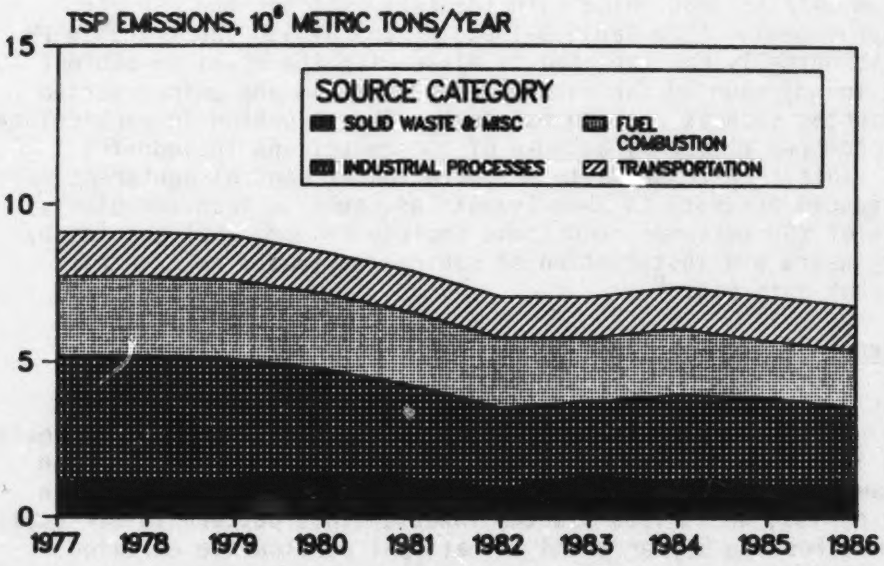

Figure 3-5. National trend in particulate emissions, 1977-1986.

Figure 3-7 focuses on the last 3 years with a bar chart of regional average TSP. It shows a consistent pattern for most regions. All regions improved between 1984 and 1986. In addition, 7 regions had their lowest levels of TSP in 1986.

TSP levels between 1985 and 1986 were down in most regions, but showed essentially no average change for the nation. This contrasts with a 4 percent improvement in particulate matter emissions. The apparent discrepancy between air quality and emission changes may be due to meteorology or uninventoried emissions.

Year-to-year variations in total suspended particulate levels may in part be attributable to meteorology. Among all meteorological parameters, precipitation has been shown to have had the greatest influence on particulate air quality. Rainfall has the effect of reducing reentrainment of particles and washing particles out of the air. An examination of regional precipitation patterns shows that the three regions (III, IV and V) with 1985-1986 TSP increases were also the only regions which experienced decreases in total precipitation, relative to normal.[13] Although these decreases in precipitation were only 5-10 percent, they probably contributed to air quality degradation in these areas. In contrast, the seven regions which showed air quality improvement between 1985 and 1986 experienced increases in precipitation. The largest improvement, in fact, occurred in the northwest (Region X), where 1985 was unusually dry and 1986 marked a return to normal precipitation.

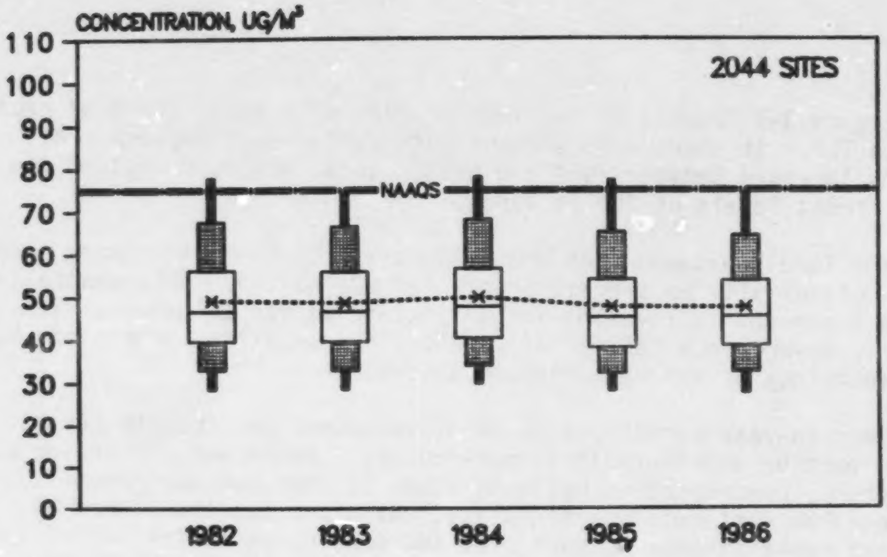

Figure 3-6. Boxplot comparisons of trends in annual mean total suspended particulate concentrations at 2044 sites, 1982-1986.

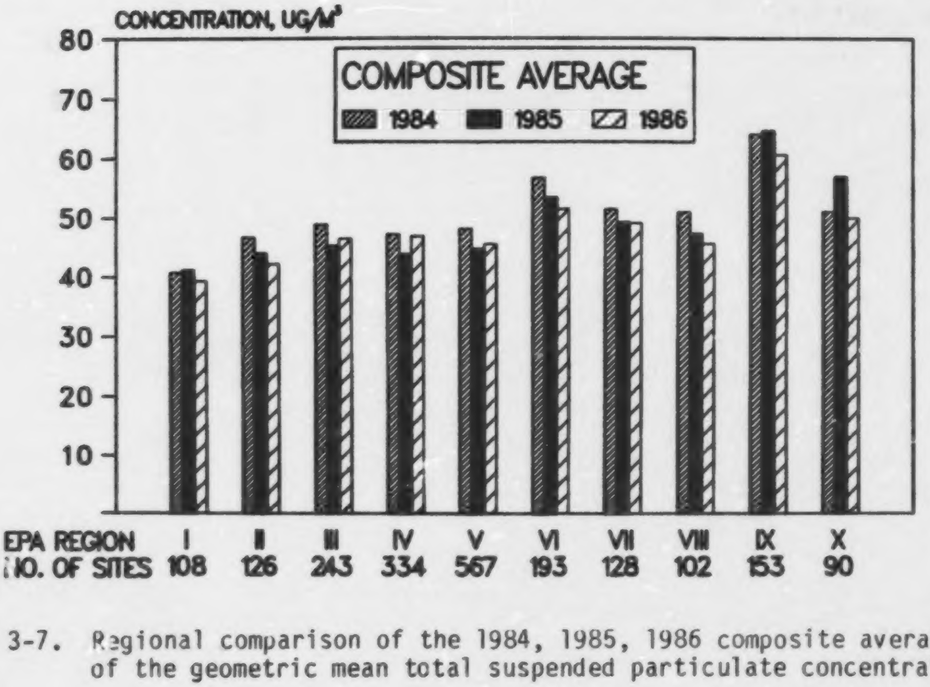

Figure 3-7. Regional comparison of the 1984, 1985, 1986 composite average of the geometric mean total suspended particulate concentration.

3.2 TRENDS IN SULFUR DIOXIDE

Ambient sulfur dioxide (SO_2) results primarily from stationary source coal and oil combustion and from nonferrous smelters. There are three NAAQS for SO_2: an annual arithmetic mean of 0.03 ppm (80 ug/m^3), a 24-hour level of 0.14 ppm (365 ug/m^3) and a 3-hour level of 0.50 ppm (1300 ug/m^3). The first two standards are primary (health-related) standards, while the 3-hour NAAQS is a secondary (welfare-related) standard. The annual standard is not to be exceeded, while the short-term standards are not to be exceeded more than once per year. The trend analyses which follow are presented for the primary standards.

The trends in ambient concentrations are derived from continuous monitoring instruments which can measure as many as 8760 hourly values per year. The SO_2 measurements reported in this section are summarized into a variety of summary statistics which relate to the SO_2 NAAQS. The statistics on which ambient trends will be reported are the annual arithmetic mean concentration, the second highest annual 24-hour average (measured midnight to midnight), and the expected annual number of 24-hour exceedances of the 24-hour standard of 0.14 ppm.

3.2.1 Long-term SO_2 Trends: 1977-86

The long-term trend in ambient SO_2, 1977 to 1986, is graphically presented in Figures 3-8 to 3-10. In each figure, the trend at the NAMS is contrasted with the trend at all sites. For each of the statistics presented, a steady downward trend is evident through 1986. Nationally, the annual mean SO_2, examined at 302 sites, decreased at a median rate of approximately 4 percent per year; this resulted in an overall change of about 37 percent (Figure 3-8). The subset of 103 NAMS recorded higher average concentrations but declined at a slightly higher rate of 6 percent per year.

The annual second highest 24-hour values displayed a similar decline between 1977 and 1986. Nationally, among 295 stations with adequate trend data, the median rate of change was 6 percent per year with an overall decline of 43 percent (Figure 3-9). The 102 NAMS exhibited a similar rate of improvement for an overall change of 45 percent. The estimated number of exceedances also showed declines for the NAMS as well as the composite of all sites (Figure 3-10). The vast majority of SO_2 sites, however, do not show any exceedances of the 24-hour NAAQS. Most of the exceedances as well as the bulk of the improvements occurred at source oriented sites including a few smelter sites in particular. The national composite estimated number of exceedances decreased 98 percent from 1977 to 1986.

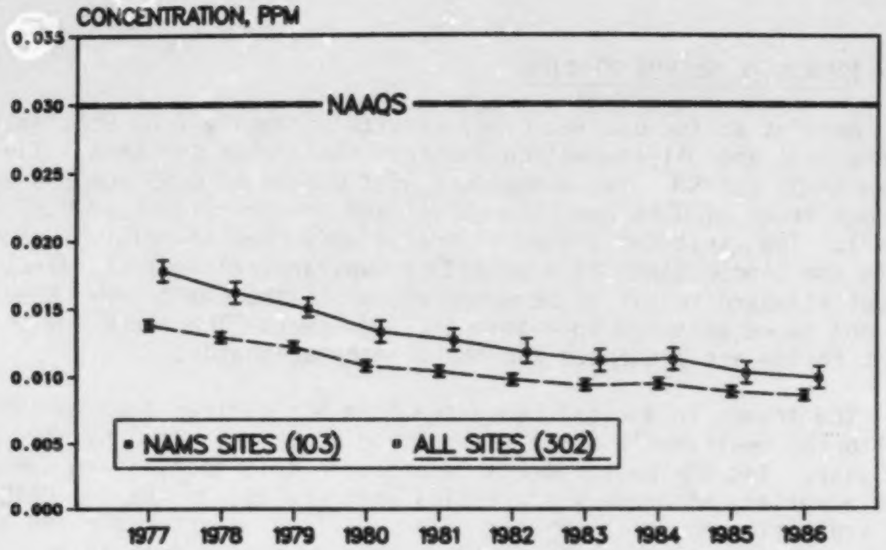

Figure 3-8. National trend in the composite average of the annual average sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

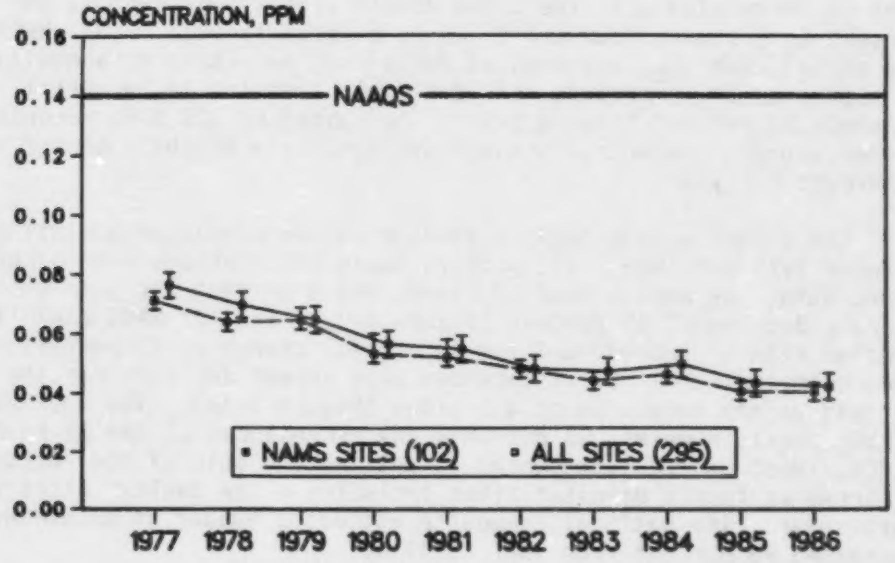

Figure 3-9. National trend in the composite average of the second-highest 24-hour sulfur dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

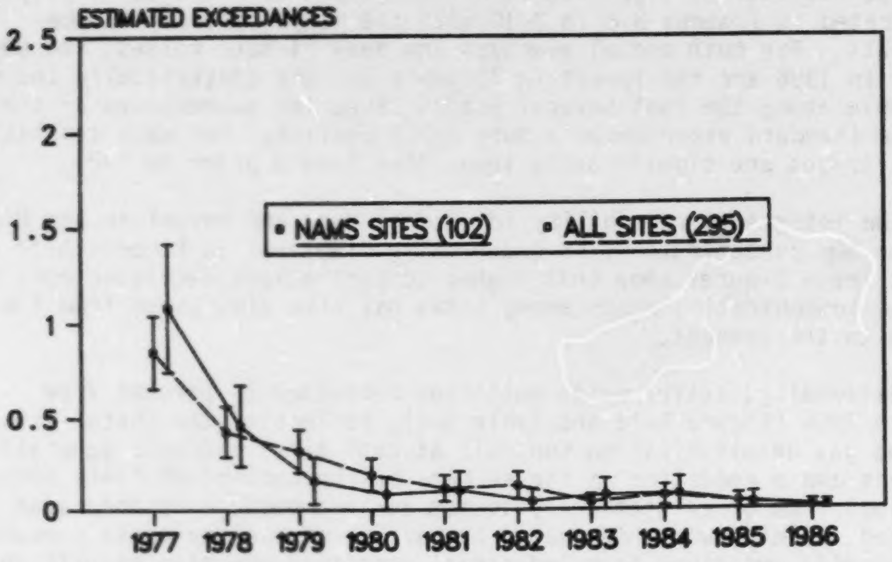

Figure 3-10. National trend in the composite average of the estimated number of exceedances of the 24-hour sulfur dioxide NAAQS at both NAMS and all sites with confidence intervals, 1977-1986.

The statistical significance of these long-term trends is graphically illustrated in Figures 3-8 to 3-10 with the 95 percent confidence intervals. For both annual averages and peak 24-hour values, the SO_2 levels in 1986 are the lowest in 10 years but are statistically indistinguishable among the last several years. Expected exceedances of the 24-hour standard experienced a more rapid decline. For each statistic, 1986 averages are significantly lower than levels prior to 1983.

The inter-site variability for annual mean and annual second highest 24-hour SO_2 concentrations is graphically displayed in Figures 3-11 and 3-12. These figures show that higher concentrations decreased more rapidly and the concentration range among sites has also diminished from the late 1970's to the present.

Nationally, sulfur oxide emissions decreased 21 percent from 1977 to 1986 (Figure 3-13 and Table 3-2), reflecting the installation of flue gas desulfurization controls at coal-fired electric generating stations and a reduction in the average sulfur content of fuels consumed. Emissions from other stationary source fuel combustion sectors also declined, mainly due to decreased combustion of coal by these consumers. Sulfur oxide emissions from industrial processes are also significant. Emissions from industrial processes have declined, primarily as the result of controls implemented to reduce emissions from nonferrous smelters and sulfuric acid manufacturing plants.[8]

The disparity between the 37 percent decrease in SO_2 air quality and the 21 percent decrease in SO_2 emissions can be attributed to several factors. SO_2 monitors with sufficient historical data for trends are mostly urban population-oriented and as such do not monitor many of the major emitters which tend to be located in more rural areas. Among the 302 trend sites used in the analysis of average SO_2 levels, two-thirds are categorized as population-oriented. The remaining sites include those monitors in the vicinity of large power plants, nonferrous smelters and other industrial sources such as paper mills and steel producing facilities.

The residential and commercial areas, where most monitors are located, have shown sulfur oxide emission decreases comparable to SO_2 air quality improvement. These decreases in sulfur oxide emissions are due to a combination of energy conservation measures and the use of cleaner fuels in the residential and commercial areas.[8] Comparable SO_2 trends have also been demonstrated for monitors located in the vicinity of nonferrous smelters which produce some of the highest SO_2 concentrations observed nationally.[7] Smelter sources represent a majority of SO_2 emissions in the intermountain region of the western U.S.

Although one-third of the trend sites are categorized as source-oriented, the majority of SO_2 emissions are dominated by large point sources. Two-thirds of all national SO_2 emissions are generated by electric utilities (94 percent of which come from coal fired power plants). The majority of these emissions, however, are produced by a small number

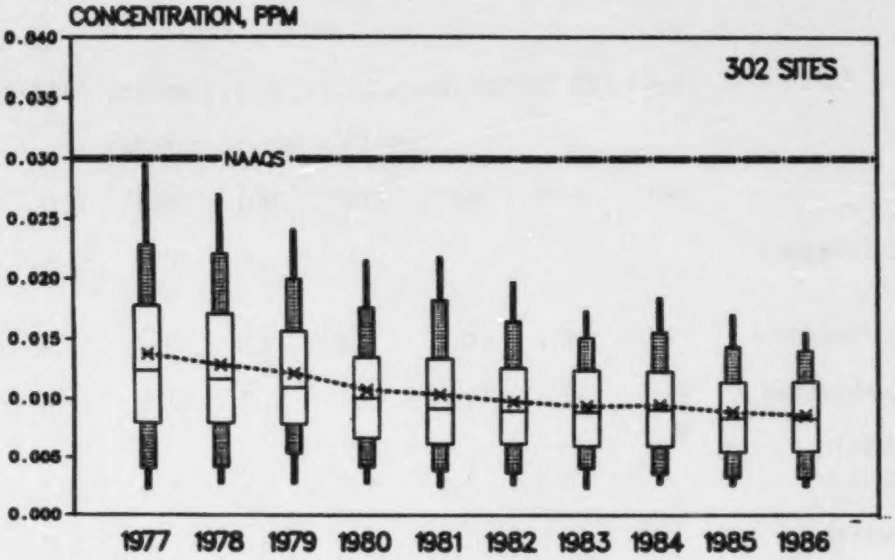

Figure 3-11. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 302 sites, 1977-1986.

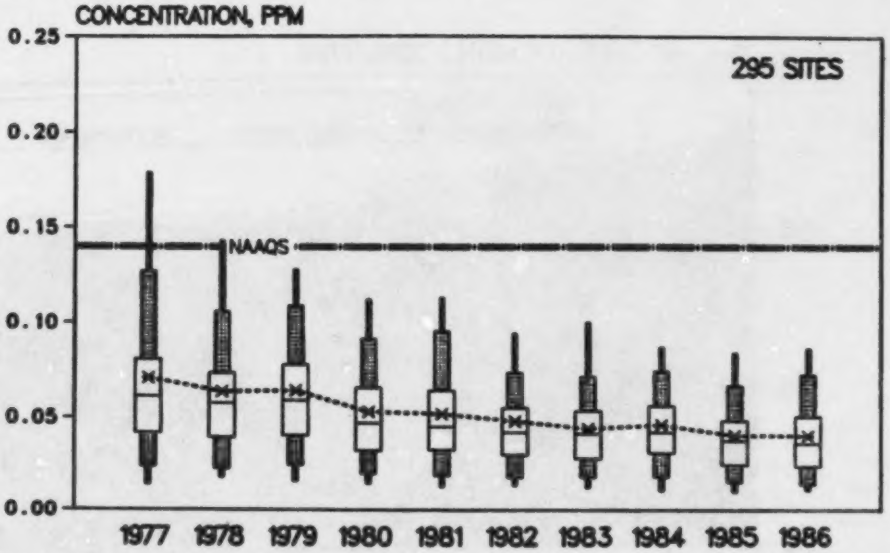

Figure 3-12. Boxplot comparisons of trends in second highest 24-hour average sulfur dioxide concentrations at 295 sites, 1977-1986.

Table 3-2. National Sulfur Oxide Emission Estimates, 1977-1986.

(million metric tons/year)

Source Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Transportation	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.9
Fuel Combustion	21.5	19.9	19.8	19.3	18.8	17.8	17.4	17.9	17.6	17.2
Industrial Processes	4.7	4.3	4.4	3.8	3.9	3.3	3.3	3.3	3.2	3.1
Solid Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Miscellaneous	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	26.9	25.0	25.1	23.9	23.5	22.0	21.5	22.1	21.6	21.2

NOTE: The sum of sub-categories may not equal total due to rounding.

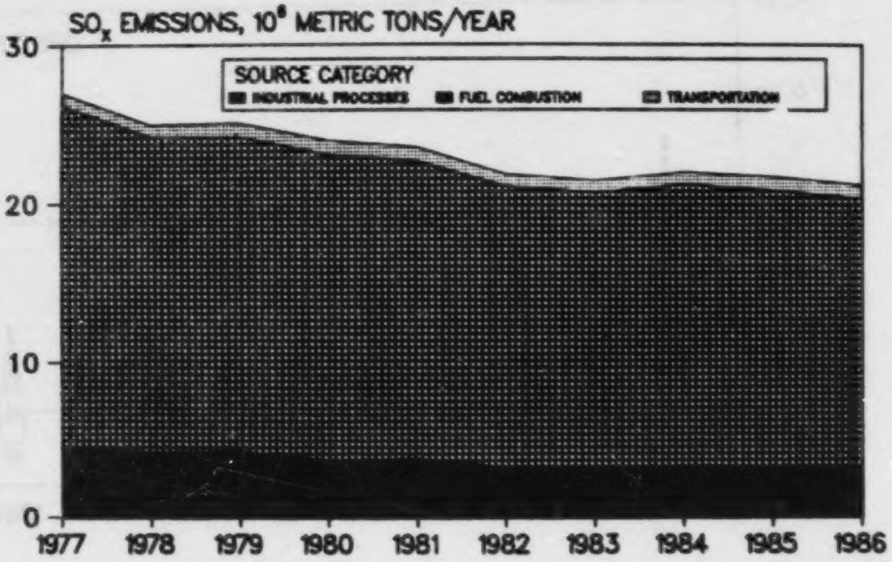

Figure 3-13. National trend in sulfur oxide emissions, 1977-1986.

of facilities. Fifty-three individual plants in 14 states account for one-half of all power plant emissions.[14] In addition, the 200 highest SO_2 emitters account for more than 85 percent of all SO_2 power plant emissions.[14,15] These 200 plants account for 57 percent of all SO_2 emissions, nationally.

Another factor which may account for differences in SO_2 emissions and ambient air quality is stack height. The height at which SO_2 is released into the atmosphere has been increasing at industrial sources and power plants.[16,17] This can permit ground level concentrations to decrease at a faster rate than emissions. Under these circumstances, concentrations can, in fact, decrease even if emissions increase.

3.2.2. Recent SO_2 Trends: 1982-86

Figure 3-14 presents boxplots for the 1982-1986 data using 583 SO_2 sites. The 5-year trend shows an 11 percent decline in average concentrations indicating that the long term trend has continued, but has been leveling off. Correspondingly, SO_2 emissions have only decreased 4 percent over the last 5 years.

Regional changes in composite average SO_2 concentrations for the last 3 years, 1984-1986, are shown in Figure 3-15. Most regions decreased slightly. Between 1985 and 1986, average ambient concentrations have declined 3 percent, corresponding to a 2 percent decrease in total emissions.

Some of the regions with the lowest average SO_2 also contain some of the highest SO_2 concentrations recorded nationally. This phenomenon which is due to SO_2 in the vicinity of nonferrous smelters, is evident in Figure 3-16 which shows the 1986 intraregional concentration distributions. Large intraregional variability in SO_2 concentrations is seen in Regions VI,VIII and X because of monitors located in the vicinity of smelters.

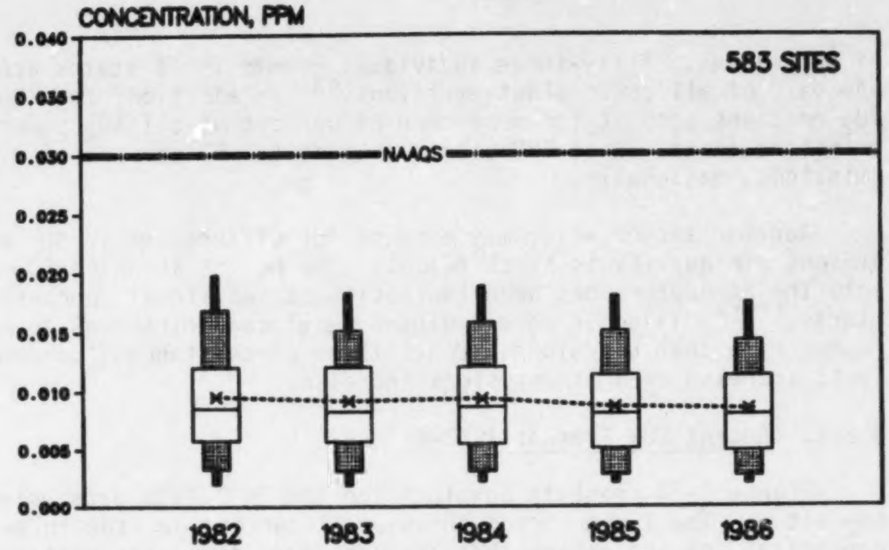

Figure 3-14. Boxplot comparisons of trends in annual mean sulfur dioxide concentrations at 583 sites, 1982-1986.

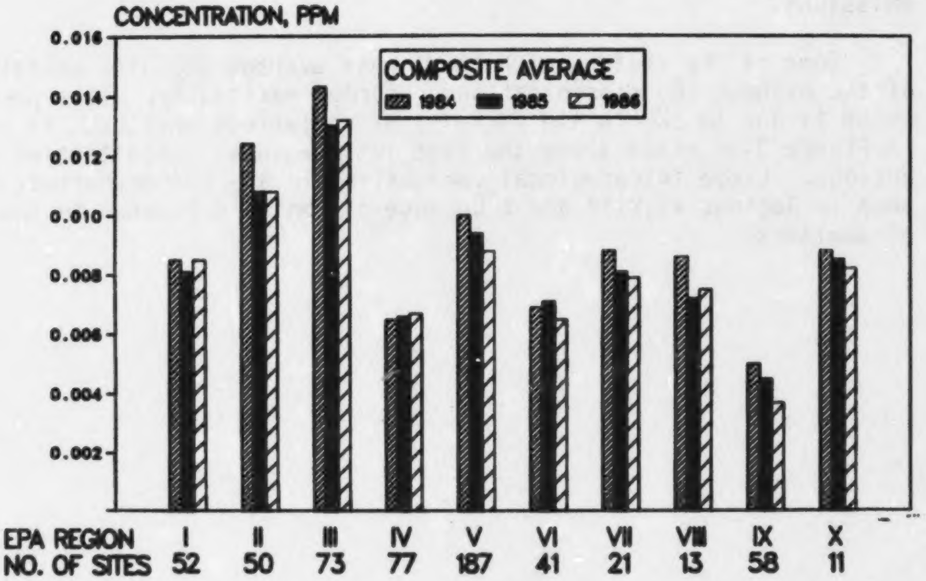

Figure 3-15. Regional comparison of the 1984, 1985, 1986 composite average of the annual average sulfur dioxide concentration.

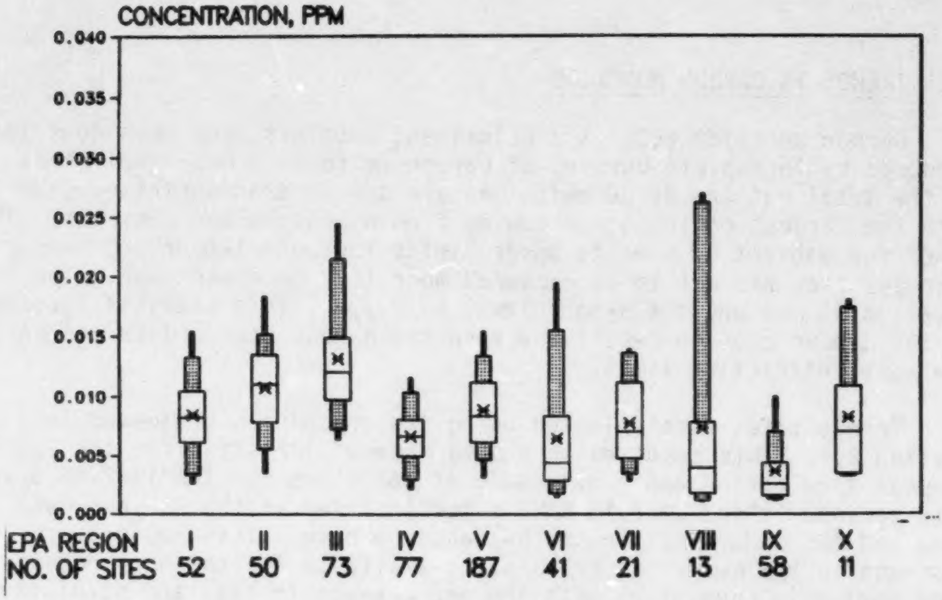

Figure 3-16. Regional boxplot comparisons of the annual average sulfur dioxide concentrations in 1986.

3.3 TRENDS IN CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless, and poisonous gas produced by incomplete burning of carbon in fuels. Over two-thirds of the total nationwide CO emissions are due to transportation sources with the largest contribution coming from highway motor vehicles. The NAAQS for ambient CO specify upper limits for both 1-hour and 8-hour averages that are not to be exceeded more than once per year. The 1-hour level is 35 ppm and the 8-hour level is 9 ppm. This analysis focuses on the 8-hour average results because the 8-hour standard is generally the more restrictive limit.

Trends sites were selected using the procedures presented in Section 2.1. This resulted in a data base of 182 sites for the 1977-86 10-year time period and a data base of 363 sites for the 1982-86 5-year time period. There were 46 NAMS sites included in the 10-year data base and 105 NAMS sites in the 5-year data base. This two-fold increase in the number of trend sites available for the more recent time period is consistent with the improvement in size and stability of current ambient CO monitoring programs.

3.3.1 Long-term CO Trends: 1977-86

The national 1977-86 composite average trend is shown in Figure 3-17 for the second highest non-overlapping 8-hour CO value for the 182 long-term trend sites and the subset of 46 NAMS sites. During this 10-year period, the national composite average decreased by 32 percent and the subset of NAMS decreased by 27 percent. The median rate of improvement for this time period is approximately 4 percent per year. There is a leveling off between 1985 and 1986 with no significant change but both years are significantly better than 1984 and earlier years for the national sample. Long-term improvement was seen at 85 percent of these trend sites. This same trend is shown in Figure 3-18 using a box plot presentation which provides more information on the distribution of ambient CO levels from year to year at the 182 long-term trend sites. While there is some year to year fluctuation in certain percentiles, the general long-term improvement in ambient CO levels is clear.

Figure 3-19 displays the 10-year trend in the composite average of the estimated number of exceedances of the 8-hour CO NAAQS. This exceedance rate was adjusted to account for incomplete sampling. The trend in exceedances shows long-term improvement but the rates are much more pronounced than those for the second maximums. The composite average for estimated exceedances improved 89 percent between 1977 and 1986 for the 182 long-term trend sites while the subset of 46 NAMS showed an almost identical 88 percent improvement. These percentage improvements for exceedances are typically much larger than those found for peak concentrations, such as the annual second maximum. The percentage change for the second maximums is more likely to reflect the percentage change in emission levels.

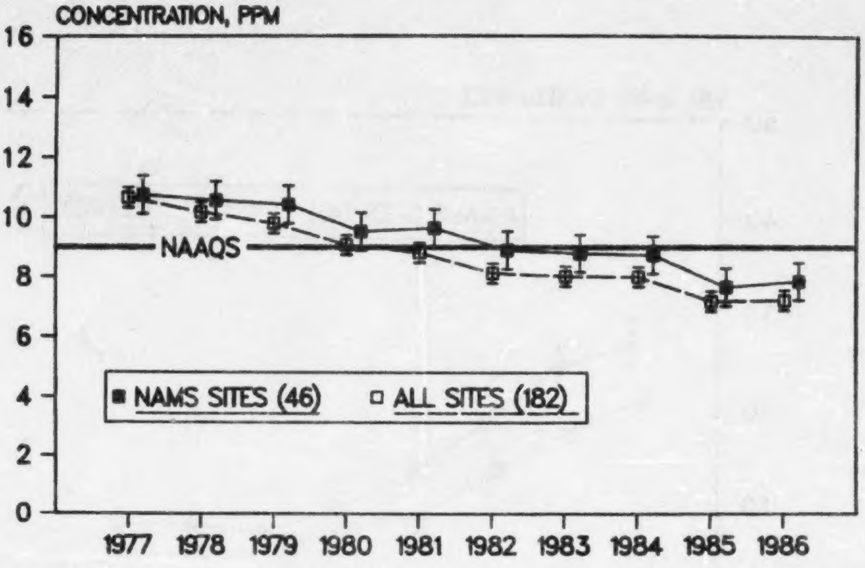

Figure 3-17. National trend in the composite average of the second highest nonoverlapping 8-hour average carbon monoxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

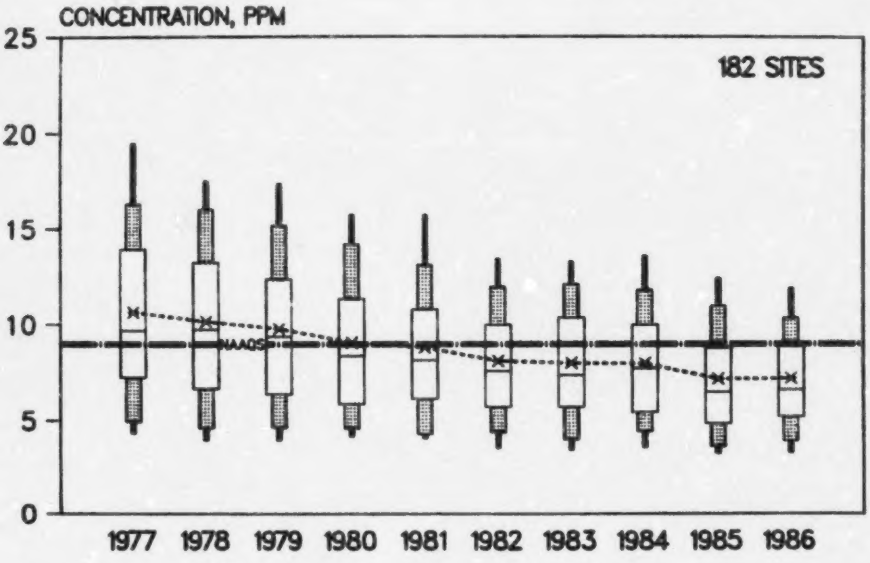

Figure 3-18. Boxplot comparisons of trends in second highest nonoverlapping 8-hour average carbon monoxide concentrations at 182 sites, 1977-1986.

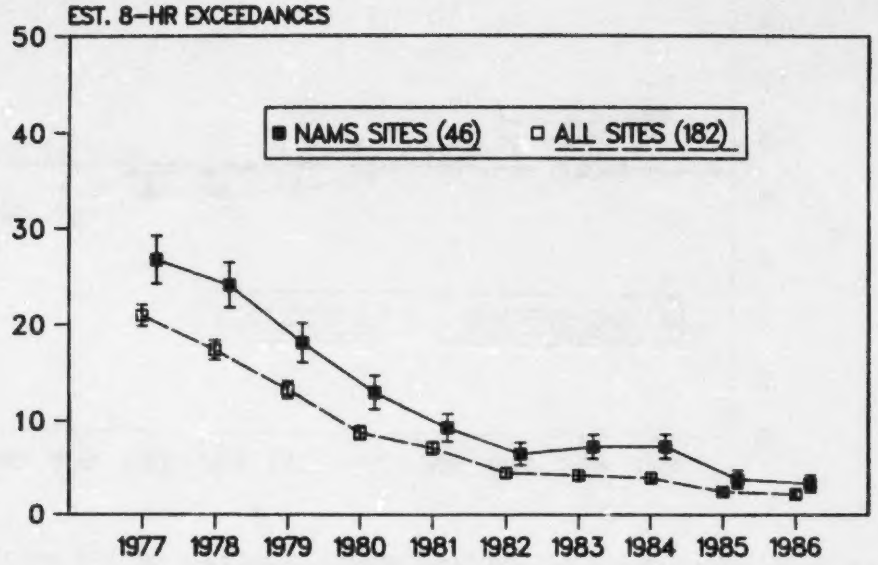

Figure 3-19. National trend in the composite average of the estimated number of exceedances of the 8-hour carbon monoxide NAAQS, at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

Table 3-3. National Carbon Monoxide Emission Estimates, 1977-1986.
(million metric tons/year)

Source Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Transportation	61.0	60.3	55.9	52.6	51.6	48.1	48.3	48.4	45.2	42.6
Fuel Combustion	5.1	5.8	6.6	7.3	7.5	8.0	7.9	8.1	7.2	7.2
Industrial Processes	7.3	7.2	7.1	6.3	5.9	4.4	4.4	4.8	4.6	4.5
Solid Waste	2.6	2.5	2.3	2.2	2.1	2.0	1.9	1.9	2.0	1.7
Miscellaneous	5.8	5.7	6.5	7.6	6.4	4.9	7.7	6.3	5.3	5.0
Total	81.8	81.4	78.3	76.1	73.4	67.4	70.3	69.6	64.3	60.9

NOTE: The sum of sub-categories may not equal total due to rounding.

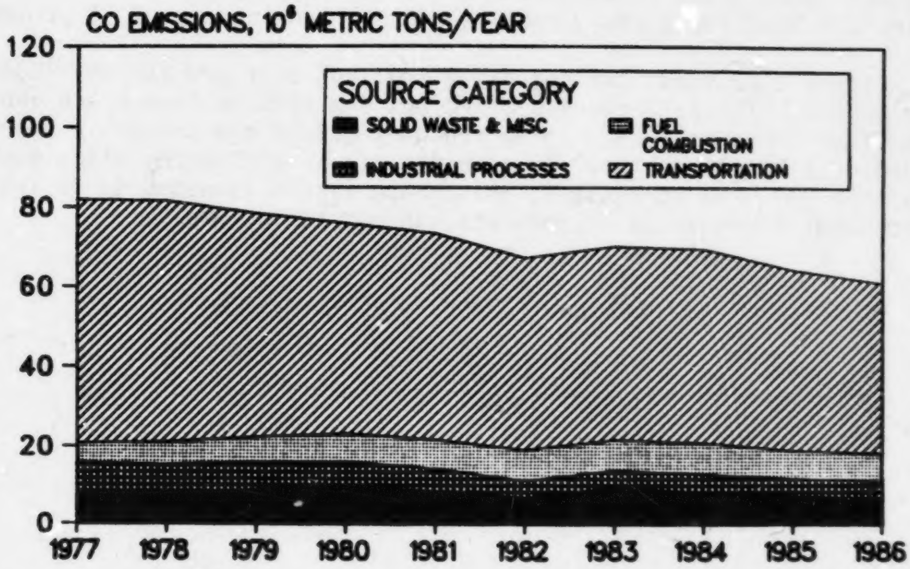

Figure 3-20. National trend in emissions of carbon monoxide, 1977-1986.

The 10-year 1977-86 trend in national carbon monoxide emission estimates is shown in Figure 3-20 and presented in Table 3-3. These estimates show a 26 percent decrease between 1977 and 1986. Transportation sources account for approximately 70 percent of the total and decreased by 30 percent over the 10-year period. The contribution from highway vehicles decreased 34 percent during the 1977-86 time period despite a 24 percent increase in vehicle miles of travel. This indicates that the Federal Motor Vehicle Control Program (FMVCP) has been effective on the national scale with controls more than offsetting growth during this period. While there is general agreement between the air quality and emission changes over this 10-year period, it is worth noting that the emission changes reflect estimated national totals while the ambient CO monitors are frequently located to identify problems. The mix of vehicles and the change in vehicle miles of travel in the area around a typical CO monitoring site may differ from the national averages.

3.3.2 Recent CO Trends: 1982-86

This section examines ambient CO trends for the 5-year time period 1982-86. As discussed in section 2.1, this allows the use of a larger data base, 363 sites versus 182. Figure 3-21 displays the 5-year ambient CO trend in terms of the second highest non-overlapping 8-hour averages. These sites showed a 13 percent improvement between 1982 and 1986. The general patterns are consistent with the longer term data base and, again, 1985 and 1986 levels are basically the same and indicate improvement relative to previous years. Table 3-3 indicates that estimated total CO emissions decreased 10 percent during this 5-year period and that the highway vehicle contribution decreased 14 percent.

Figure 3-22 shows the composite regional averages for the 1984-86 time period. The patterns are mixed but the 1985-86 levels are generally lower than those in 1984. These regional graphs are primarily intended to depict relative change. Because the mix of monitoring sites may vary from one area to another, this graph is not intended to be indicative of regional differences in absolute concentration levels.

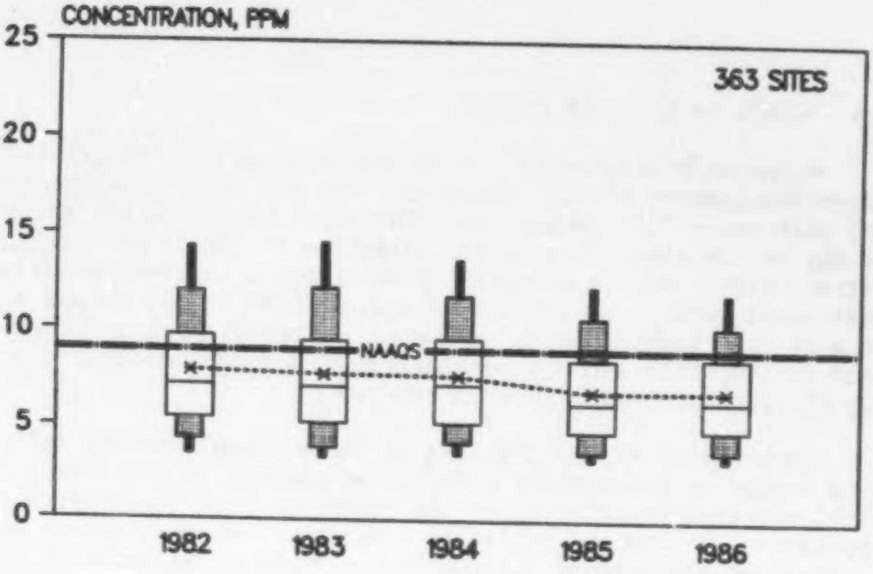

Figure 3-21. Boxplot comparisons of trends in second highest nonoverlapping 8-hour average carbon monoxide concentrations at 363 sites, 1982-1986.

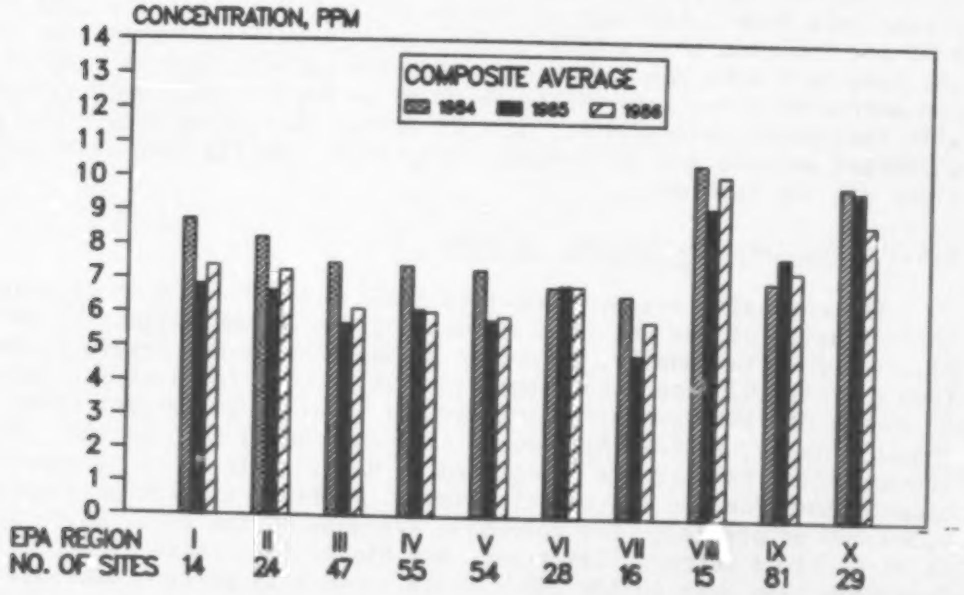

Figure 3-22. Regional comparison of the 1984, 1985, 1986 composite average of the second highest nonoverlapping 8-hour average carbon monoxide concentration.

3.4 TRENDS IN NITROGEN DIOXIDE

Nitrogen dioxide (NO_2), a yellowish brown gas, is present in urban atmospheres through emissions from two major sources, transportation and stationary fuel combustion. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant, nitric oxide. NO_2 is measured using either a continuous monitoring instrument, which can collect as many as 8760 hourly values a year, or a 24-hour bubbler, which collects one measurement per 24-hour period. Both monitors are used to compare annual average concentrations with the NO_2 standard of 0.053 parts per million.

In order to expand the size of the available trends data base, data were merged at sites which experienced changes in the agency operating the site, the instrument used, or the designation of the project code, such as population oriented or duplicate sampling. The merging was accomplished by treating the bubbler and continuous hourly data separately. For example, if a monitor at a given site was changed from a 24-hour bubbler to a continuous hourly monitor, the data would not be merged. If, however, a monitor at a given site changed from one type of continuous instrument to another type of continuous instrument, the data would be merged.

The trends site selection process, described in Section 2.1, yielded 111 sites for the 1977-86 10-year period and 228 sites for the 1982-86 5-year data base. Thirteen of the long-term trend sites are NAMS while 52 NAMS are included in the 1982-86 data base. Until this year, the size of the long-term data base had been decreasing each successive year as low concentration sites were discontinued or as NO_2 bubblers were replaced with continuous instruments. In this latter case, data from these two different methods are not merged. Only 22 of the 111 long-term trend sites are NO_2 bubblers.

3.4.1 Long-term NO_2 Trends: 1977-86

The composite average long-term trend for the nitrogen dioxide mean concentration at the 111 trend sites, and the 13 NAMS sites, is shown in Figure 3-23. Nationally, composite annual average NO_2 levels increased from 1977 to 1979, decreased through 1986, except for a slight increase in 1984. The 1986 composite average NO_2 level is 14 percent lower than the 1977 level, indicating a downward trend during this period. Of the 111 trends sites, only 13 are designated as NAMS. This is to be expected because NAMS for NO_2 are only located in urban areas with populations of 1,000,000 or greater. The composite averages of the NAMS, which are located in eight large metropolitan areas, are higher than those of all sites. Comparing 1986 data to the 1977 levels shows a 14 percent decrease in the composite average for all trends sites and a 9 percent decrease for the NAMS. The discrepancy between the all sites and NAMS year to year changes may be attributed to both the small number of NAMS meeting the 10-year trends completeness criteria and the generally low levels of recorded NO_2 annual mean concentrations, with respect to the level of the NO_2 NAAQS.

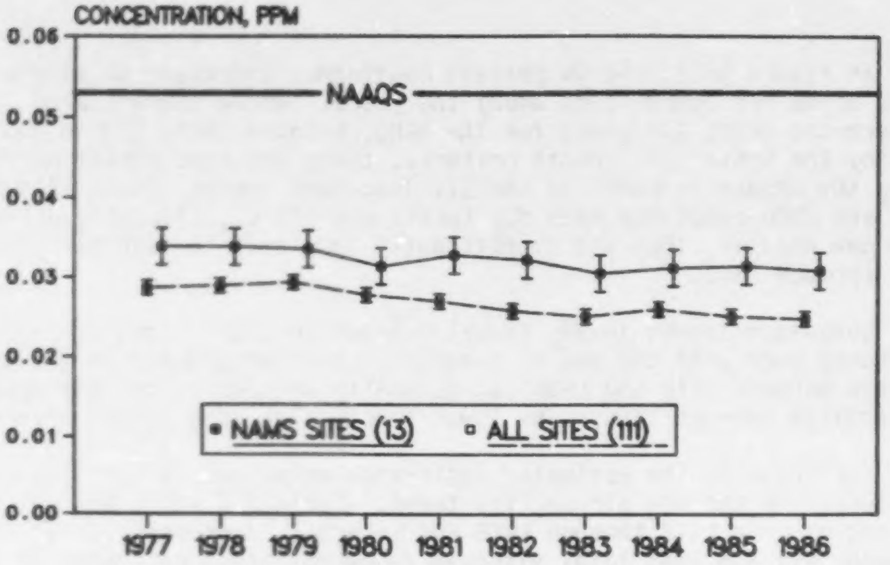

Figure 3-23. National trend in the composite average of nitrogen dioxide concentration at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

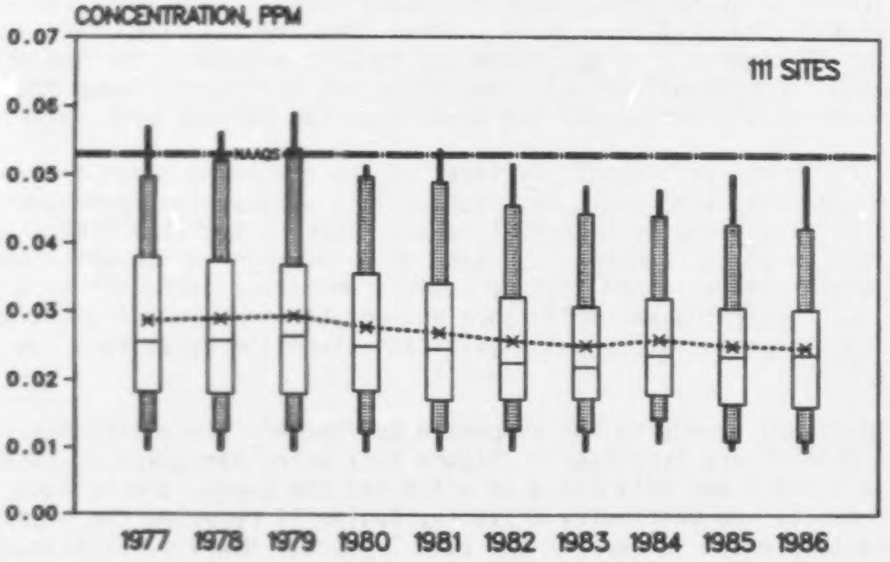

Figure 3-24. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 111 sites, 1977-1986.

In Figure 3-23, the 95 percent confidence intervals about the composite means allow for comparisons among the years. While there are no significant differences among the years for the NAMS, because there are so few sites meeting the historical trends criteria, there are significant differences among the composite means of the 111 long-term trends sites. Although the 1985 and 1986 composite mean NO_2 levels are not significantly different from one another, they are significantly less than the earlier years 1977 through 1981.

Long-term trends in NO_2 annual average concentrations are also displayed in Figure 3-24 with the use of boxplots. The improvement in the composite average between 1979 and 1986 can generally be seen in the the upper percentiles through 1984. The lower percentiles show little change, however.

The trend in the estimated nationwide emissions of nitrogen oxides (NO_x) is similar to the NO_2 air quality trend. Table 3-4 shows NO_x emissions increasing from 1977 through 1978 and generally decreasing until 1984. Between 1977 and 1986 total nitrogen oxide emissions decreased by 8 percent, but highway vehicle emissions, the source category likely impacting the majority of urban NO_2 sites, decreased by 13 percent. This decrease in the highway vehicle category is consistent with the long-term decrease in NO_2 levels of 14 percent. Figure 3-25 shows that the two primary source categories of nitrogen oxide emissions are fuel combustion and transportation, comprising 52 percent and 44 percent, respectively, of total 1986 nitrogen oxide emissions.

3.4.2 Recent NO_2 Trends: 1982-86

Figure 3-26 uses the boxplot presentation to display recent trends in nitrogen dioxide annual mean concentrations for the years 1982-86. Focusing on the past five years, rather than the last ten years, more than doubles the number of sites, from 111 to 228, available for the analysis. Although the composite means from the recent period are lower than the long-term means, the trends are consistent for the two data bases.

The composite average NO_2 level at the 228 trend sites decreased 1 percent between 1982 and 1986. During this same period, nitrogen oxide emissions decreased by 1 percent, also. Between 1985 and 1986, the NO_2 composite average remained constant, while nitrogen oxide emissions recorded a 2 percent decrease and highway vehicle emissions decreased by 4 percent. This small year-to-year difference between the ambient and emissions percent change is likely not significant given the relatively low ambient NO_2 levels.

Regional trends in the composite average NO_2 concentrations for the years 1984-86 are displayed in Figure 3-27 using bar graphs. Except for Region X which had only one site which met the 5-year trends data completeness and continuity criteria, Region II recorded the highest composite average in each of the past 3 years. However, as discussed in Section 4.0, the Los Angeles Metropolitan Area (Region IX) is the only area which exceeded the NO_2 standard during this period. The pattern of the year-to-year changes is mixed among the Regions. Four Regions (I, II, IV, and VIII) recorded small decreases between 1985 and 1986, Regions III and VII recorded small increases and four Regions remained unchanged (Regions V, VI, IX, and X).

Table 3-4. National Nitrogen Oxides Emission Estimates, 1977-1986.

(million metric tons/year)

Source Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Transportation	9.5	9.7	9.5	9.2	9.3	8.9	8.6	8.7	8.8	8.5
Fuel Combustion	10.4	10.3	10.5	10.1	10.0	9.8	9.6	10.2	10.2	10.0
Industrial Processes	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.6	0.6	0.6
Solid Waste	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Miscellaneous	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1
Total	21.0	21.1	21.0	20.3	20.3	19.5	19.1	19.7	19.7	19.3

NOTE: The sum of sub-categories may not equal total due to rounding.

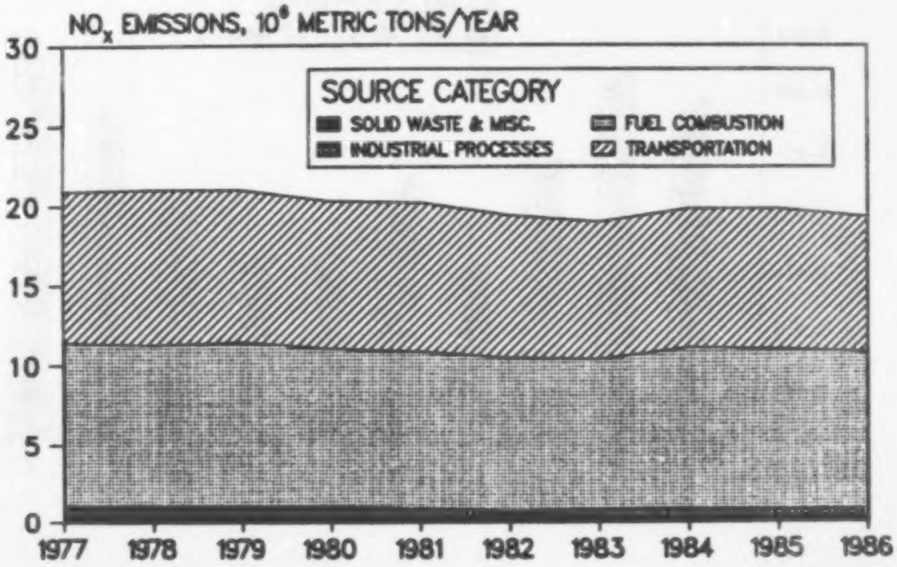

Figure 3-25. National trend in nitrogen oxides emissions, 1977-1986.

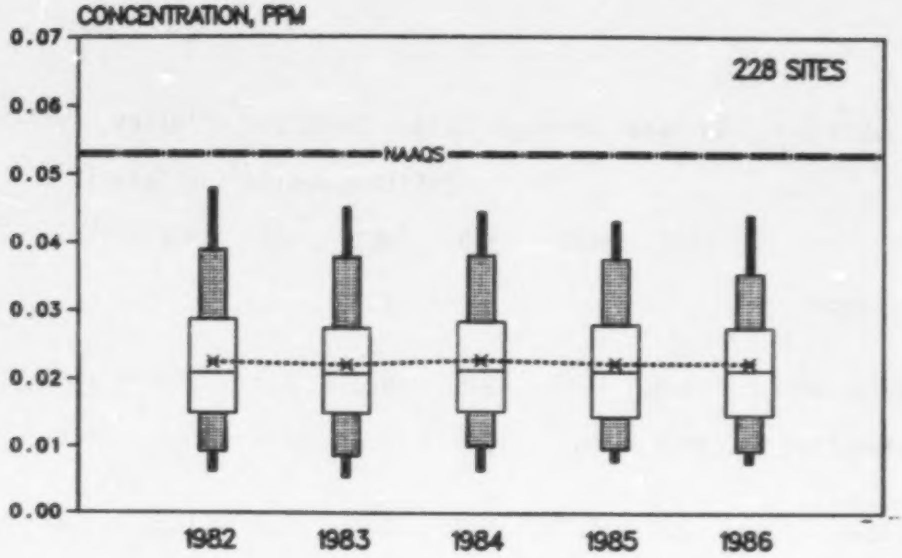

Figure 3-26. Boxplot comparisons of trends in annual mean nitrogen dioxide concentrations at 228 sites, 1982-1986.

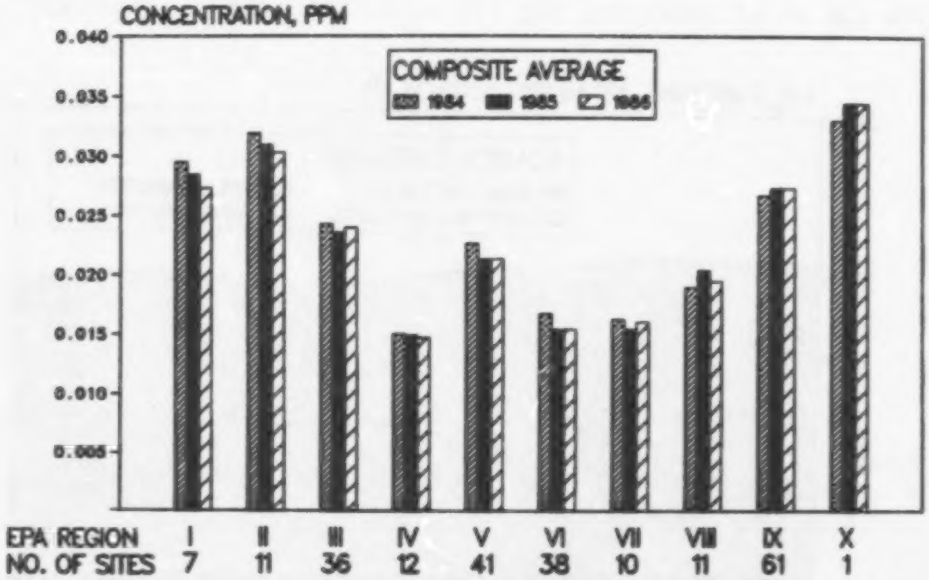

Figure 3-27. Regional comparison of 1984, 1985, 1986 composite average of the annual mean nitrogen dioxide concentration.

3.5 TRENDS IN OZONE

Ozone (O_3) is a photochemical oxidant and the major component of smog. While ozone in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation given off by the sun, high concentrations of ozone at ground level are a major health and environmental concern. Ozone is not emitted directly into the air, but is formed through complex chemical reactions between precursor emissions of volatile organic compounds and nitrogen oxides in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak ozone levels typically occur during the warmer times of the year. Both volatile organic compounds and nitrogen oxides are emitted by transportation and industrial sources. Volatile organic compounds are emitted from sources as diverse as autos, chemical manufacturing, dry cleaners, paint shops, and other sources using solvents. The strong seasonality of ozone levels makes it possible for areas to limit their ozone monitoring to a certain portion of the year, termed the ozone season. The length of the ozone season varies from one area of the country to another. May through October is typical but States in the south and southwest may monitor the entire year. More northern states would have shorter ozone seasons such as May through September for North Dakota. This analysis uses these ozone seasons on a State by State basis to ensure that the data completeness requirements are applied to the relevant portions of the year.

The O_3 NAAQS is defined in terms of the daily maximum, that is, the highest hourly average for the day, and specifies that the expected number of days per year with values greater than 0.12 ppm should not be greater than one. Both the annual second highest daily maximum and the number of daily exceedances during the ozone season are considered in this analysis.

The trends site selection process, discussed in Section 2.1, resulted in 242 sites being selected for the 1977-86 period and 539 sites qualifying for the 1982-86 5-year data base. Eighty-eight of the long-term trends sites were NAMS while 198 NAMS sites were included in the 5-year trends data base. In both cases, the 5-year data base is much larger than the 10-year data base which reflects the improvement in ambient ozone monitoring networks.

3.5.1. Long-term Ozone Trends: 1977-86

Figure 3-28 displays the 10-year composite average trend for the second high day during the ozone season for the 242 trends sites and the subset of 88 NAMS sites. Although the 1986 composite average for the 242 trend sites is 21 percent lower than the 1977 average, this comparison is affected by a calibration change for ozone measurements that occurred in the 1978-79 time period.[18] This complication has been

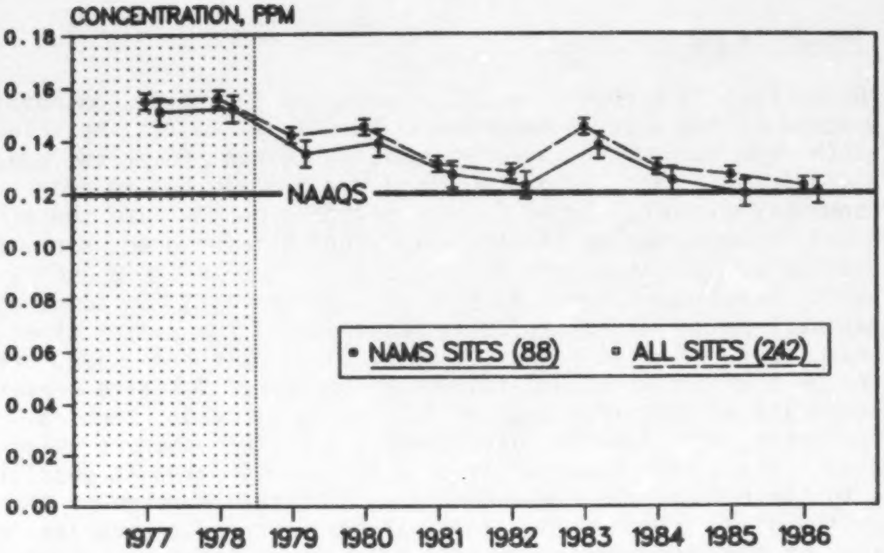

Figure 3-28. National trend in the composite average of the second highest maximum 1-hour ozone concentration at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

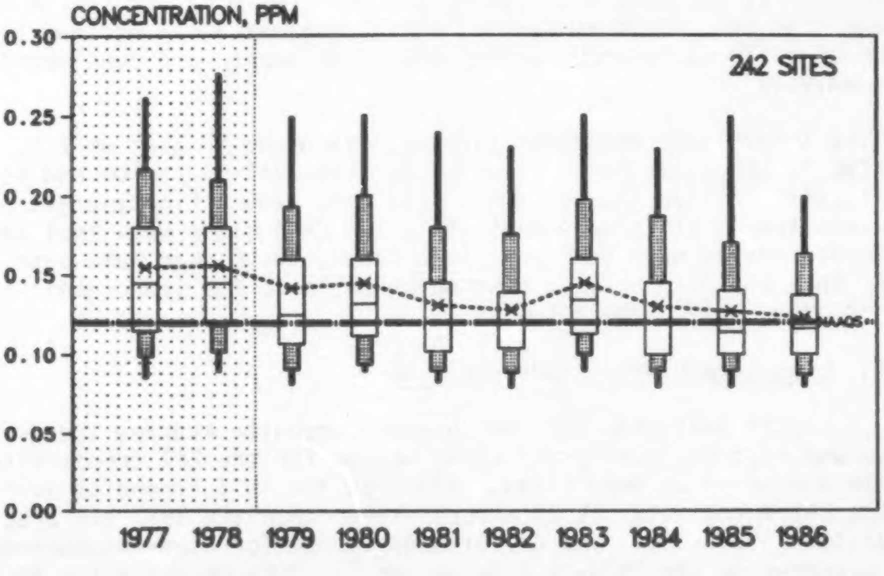

Figure 3-29. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentration at 242 sites, 1977-1986.

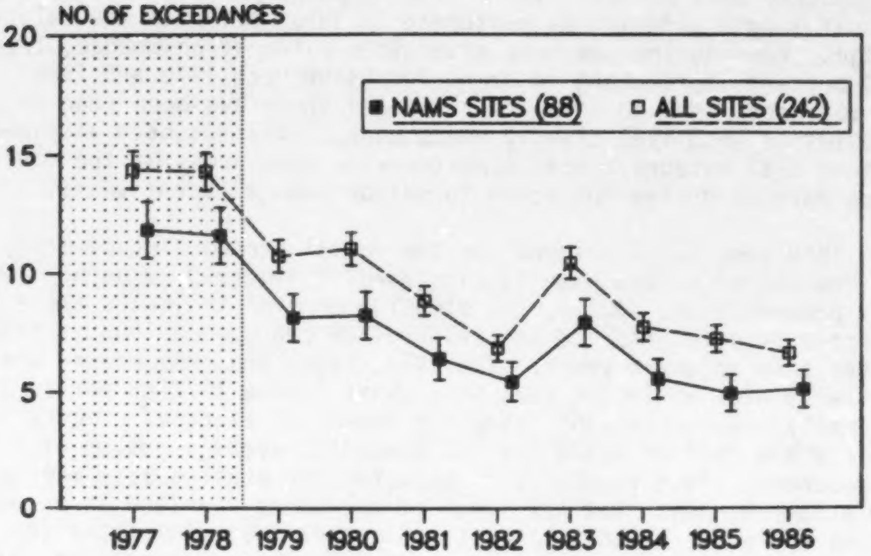

Figure 3-30. National trend in the composite average of the estimated number of daily exceedances of the ozone NAAQS in the ozone season at both NAMS and all sites with 95 percent confidence intervals, 1977-1986.

discussed in previous reports as well as the reasons that it is difficult to quantify this effect.[7,9,10] The stippled portion of Figure 3-28 indicates data affected by measurements taken prior to the calibration change. Considering the data after this calibration change, there was a 13 percent improvement in ozone levels between 1979 and 1986. This has not been a smooth downward trend and there has been year to year fluctuation with 1983 clearly being high. This has been attributed in part to 1983 meteorological conditions in some areas of the country being more conducive for ozone formation than adjacent years.

This same 10-year trend for the annual second highest daily maximum for the 242 site data base is displayed in Figure 3-29 using the boxplot presentation. Again, the stippled portion indicates those years affected by data prior to the calibration change and 1983 is clearly higher than adjacent years. The 1979, 1980, and 1983 values are similarly high while the remaining years in the 1977-86 period are generally lower with 1986 being the lowest on average. Figure 3-30 depicts the 1977-86 trend for the composite average number of ozone exceedances. This statistic is adjusted for missing data and reflects the number of days that the level of the ozone standard is exceeded during the ozone season. The stippled area again indicates the time period when comparisons would be affected by the calibration change so that the 54 percent decrease between 1977 and 1986 incorporates the effect of the calibration change. The expected number of exceedances decreased 38 percent for the 242 sites and 37 percent for the subset of 88 NAMS. As with the second maximum, the 1979, 1980, and 1983 values are higher than the other years in the 1979-86 time period.

Table 3-5 and Figure 3-31 display the 1977-86 emission trends for volatile organic compounds (VOC) which, along with nitrogen oxides, are involved in the atmospheric chemical and physical processes that result in the formation of O_3. Total VOC emissions are estimated to have decreased 19 percent between 1977 and 1986. Between 1977 and 1986, VOC emissions from highway vehicles are estimated to have decreased 39 percent despite a 24 percent increase in vehicle miles of travel during this time period. Potential difficulties in using ozone precursor emission estimates to represent ambient trends have been discussed in a recent analysis of southern California ozone trends.[19]

3.5.2 Recent Ozone Trends: 1982-86

This section discusses ambient O_3 trends for the 5-year time period 1982-86. This permits the use of a larger data base of 539 sites compared to 242 for the 10-year period. Figure 3-32 uses a boxplot presentation of the annual second maximum daily value at these 539 sites. The national composite decreased 4 percent between 1982 and 1986 while Table 3-5 indicates that total VOC emissions are estimated to have decreased by 3 percent during this period. The most obvious feature of Figure 3-32 is that 1983 levels were clearly higher than those of the other years. Previous reports[7,9,10] have discussed how these 1983 ozone levels were influenced by meteorological conditions in that year being more conducive to ozone formation than conditions in the adjacent years.

Table 3-5. National Volatile Organic Compound Emission Estimates, 1977-1986.

(million metric tons/year)

Source Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Transportation	10.0	9.7	8.9	8.2	7.9	7.4	7.3	7.3	6.7	6.5
Fuel Combustion	1.4	1.6	1.9	2.2	2.3	2.5	2.6	2.6	2.3	2.3
Industrial Processes	9.3	9.9	9.8	9.2	8.3	7.4	7.8	8.7	8.4	7.9
Non-Industrial Organic Solvent Use	1.9	1.9	2.0	1.9	1.6	1.5	1.6	1.8	1.5	1.5
Solid Waste	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Miscellaneous	0.8	0.8	0.9	1.0	0.9	0.7	1.1	0.9	0.7	0.7
Total	24.1	24.7	24.3	23.0	21.6	20.1	20.9	21.9	20.3	19.5

NOTE: The sum of sub-categories may not equal total due to rounding.

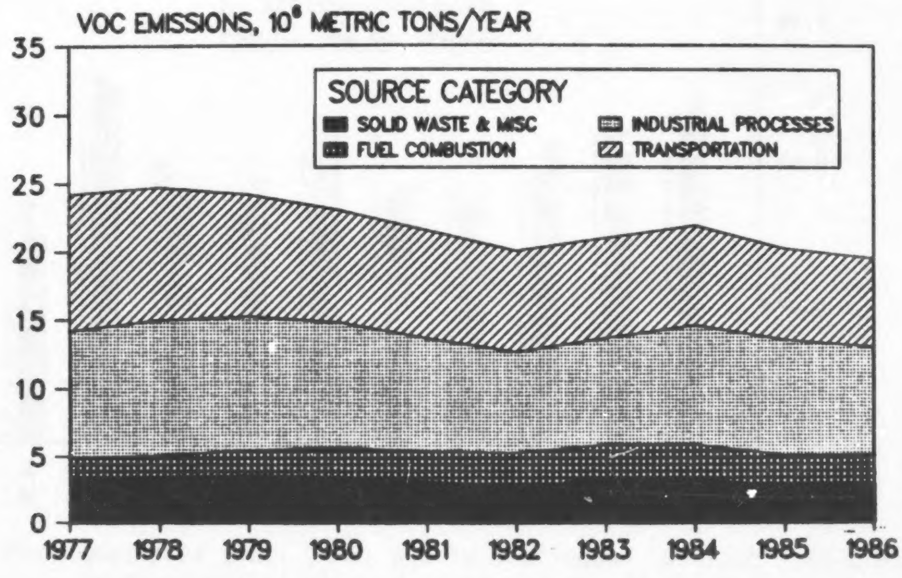

Figure 3-31. National trend in emissions of volatile organic compounds, 1977-1986.

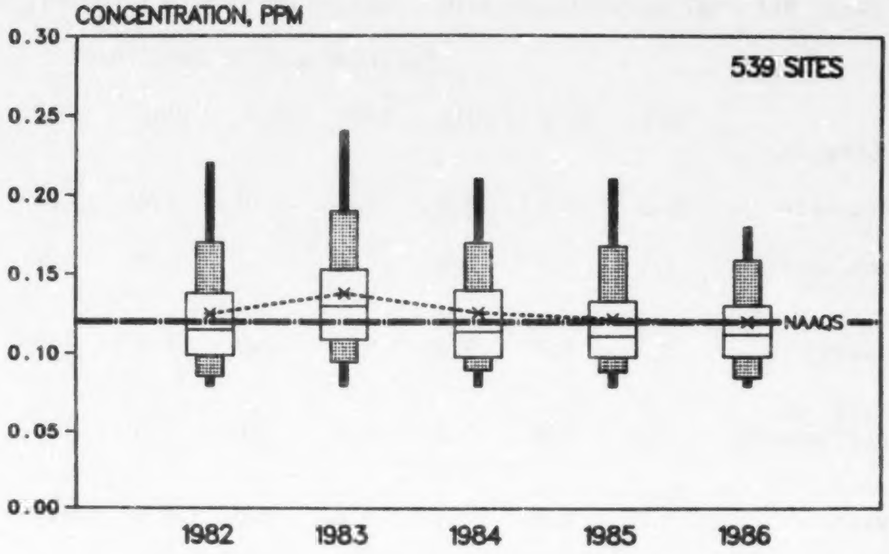

Figure 3-32. Boxplot comparisons of trends in annual second highest daily maximum 1-hour ozone concentrations at 539 sites, 1982-1986.

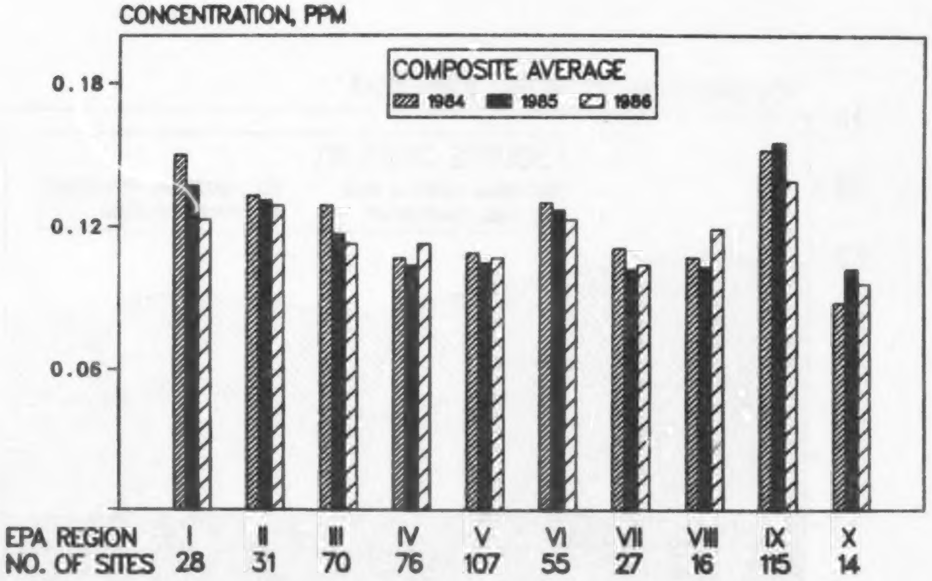

Figure 3-33. Regional comparison of the 1984, 1985, 1986 composite average of the second-highest daily 1-hour ozone concentrations.

Figure 3-33 presents a regional comparison for 1984, 1985, and 1986 of the composite average second highest daily maximum 1-hour ozone concentration. Again it is worth noting that these 1984-86 values are generally lower than those of 1983. For half of these Regions the 1986 values were the lowest of the last 3 years. It is possible that the 1986 ozone levels for the southeastern U.S. were affected by warmer temperatures. Preliminary data for 1987 suggest that meteorological conditions may again have been conducive for ozone formation and may contribute to increased ozone levels in some areas.

3.6 TRENDS IN LEAD

Lead (Pb) gasoline additives, non-ferrous smelters, and battery plants are the most significant contributors to atmospheric Pb emissions. Transportation sources in 1986 contribute about 41 percent of the annual emissions, down substantially from 73 percent in 1985. The reasons for this drop are noted below.

Prior to promulgation of the Pb standard in October 1978,[20] two air pollution control programs were implemented by EPA that have resulted in lower ambient Pb levels. First, regulations were issued in the early 1970's which required the Pb content of all gasoline to be gradually reduced over a period of many years. Most recently the Pb content of the leaded gasoline pool was reduced from an average of 1.0 grams/gallon to 0.5 grams/gallon on July 1, 1985 and still further to 0.1 grams/gallon on January 1, 1986. Second, as part of EPA's overall automotive emission control program, unleaded gasoline was introduced in 1975 for use in automobiles equipped with catalytic control devices. These devices reduce emissions of carbon monoxide, hydrocarbons and nitrogen oxides. In 1986 unleaded gasoline sales accounted for 69 percent of the total gasoline market. Additionally, Pb emissions from stationary sources have been substantially reduced by control programs oriented toward attainment of the TSP and Pb ambient standards. The overall effect of these three control programs has been a major reduction in the amount of Pb in the ambient air.

3.6.1 Long-term Lead Trends: 1977-86

Early trend analyses of ambient Pb data[21,22] were based almost exclusively on National Air Surveillance Network (NASN) sites. These sites were established in the 1960's to monitor ambient air quality levels of TSP and associated trace metals, including Pb. The sites were predominantly located in the central business districts of larger American cities. In September 1981, ambient Pb monitoring regulations were promulgated.[23] The siting criteria in the regulations resulted in the elimination of many of the old historic TSP monitoring sites as being unsuitable sites for the measurement of ambient Pb concentrations.

As with the other pollutants, the trend sites that were selected had to satisfy an annual data completeness criterion of at least 8 out of 10 years of data in the 1977 to 1986 time period. A year was included as "valid" if at least 3 of the 4 quarterly averages were available. A total of only 82 urban-oriented sites, representing 25 States, met the data completeness criterion. Only seven of these sites were NAMS sites, thereby, making this NAMS trend determination very tentative until more NAMS Pb trend sites become available. Thirty-three (40 percent) of the trend sites were located in the States of Arizona, Pennsylvania and Texas. A total of 326 sites satisfied a trend criterion for the 1982-86 period, which required 4 out of 5 years in the 1982 to 1986 time period.

The mean of the composite maximum quarterly averages and their respective 95 percent confidence intervals are shown in Figure 3-34 for both the 82 urban sites and 7 NAMS sites (1977-1986). There was an 87 percent overall (1977-86) decrease for the 82 urban sites. The confidence

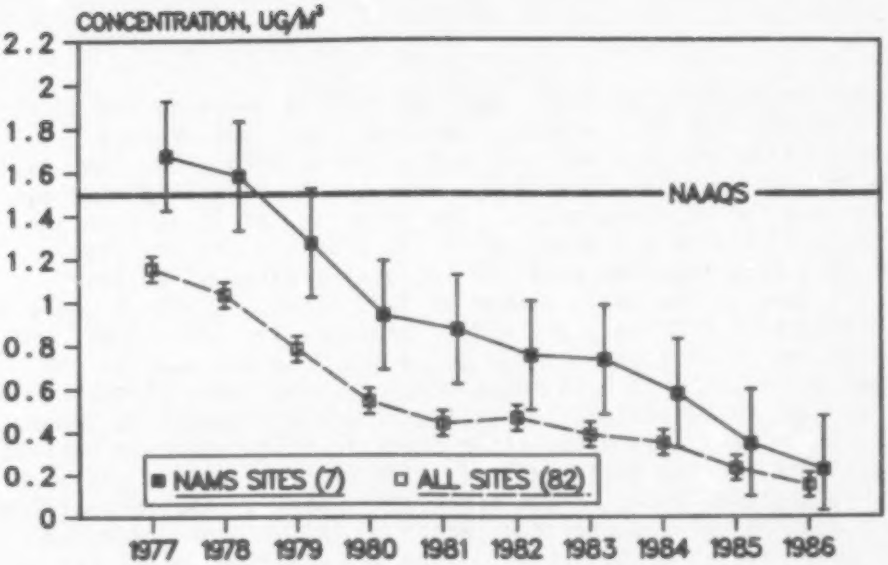

Figure 3-34. National trend in the composite average of the maximum quarterly average lead concentration at 82 sites and 7 NAMS sites with 95 percent confidence intervals, 1977-1986.

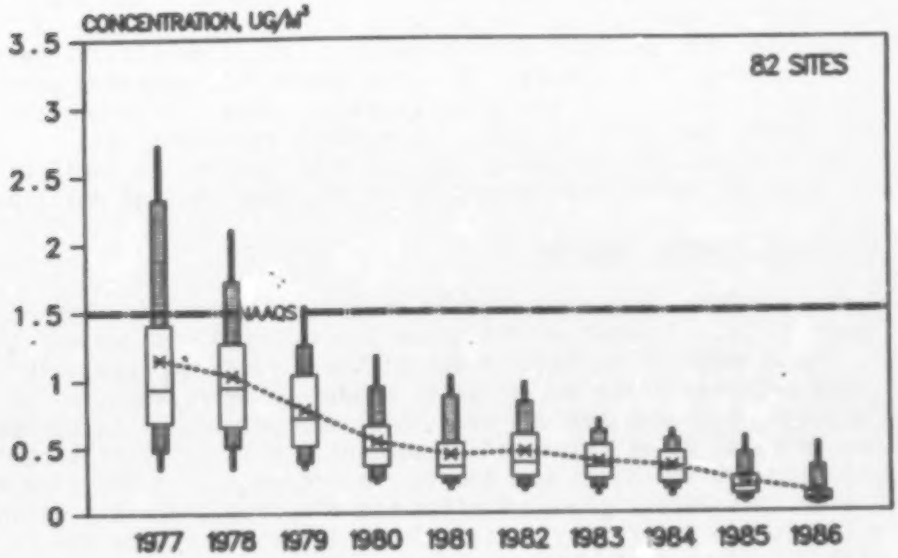

Figure 3-35. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 82 sites, 1977-1986.

intervals for these sites indicate that the 1977-79 averages are significantly different from the 1980-86 averages. Moreover, the 1986 average is statistically different from all averages prior to 1985. The 1986 average shows a 35 percent decrease from 1985. This is the largest percentage decrease for any two adjacent years. The reduction of Pb in gasoline from 1.0 grams/gallon to 0.5 grams/gallon is probably the principal reason for this drop together with the increasing sales of unleaded gasoline. Because of the small number of NAMS sites (7) with 8 years of data, the confidence intervals are wide. However, the 1984, 1985, and 1986 averages are still significantly different from averages in the 1977-79 time period. Figure 3-35 shows boxplot comparisons of the maximum quarterly average Pb concentrations at the 82 urban oriented Pb trend sites (1977-86). This figure shows the dramatic improvement in ambient Pb concentrations for the entire distribution of trend sites. As with the composite average concentration since 1977, most of the percentiles also show a monotonically decreasing pattern. The 82 urban-oriented sites that qualified as trend sites for the 1977-86 time period can be compared to the 53 sites for the 1976-85 time period in last year's report,[10] indicating the expansion of the data base in more recent years.

The trend in total lead emissions is shown in Figure 3-36. Table 3-6 summarizes the Pb emissions data as well. The drop (1977-86) in total Pb emissions was 94 percent. This compares with a 87 percent decrease (1977-86) in ambient Pb noted above. The drop in Pb consumption and subsequent Pb emissions since 1977 was brought about because of the increased use of unleaded gasoline in catalyst equipped cars and the reduced Pb content in leaded gasoline as noted above. The results of these reductions in 1986 amounted to a 59 percent reduction nationwide in total Pb emissions from 1985 levels. As noted above 1986 unleaded gasoline sales represented 69 percent of the total gasoline sales. Although the good agreement among the trend in lead consumption, emissions, and ambient levels is based upon a limited geographical sample, it does show that ambient urban Pb levels are responding to the drop in lead emissions.

3.6.2 Recent Lead Trends: 1982-86

Ambient Pb trends were also studied over the shorter time period 1982-86 (Figure 3-37). A total of 326 urban sites from 43 states met the minimum data requirement of at least 4 out of the 5 years of data. This larger and more representative set of sites showed an improvement of 68 percent in average Pb concentrations over this time period. This corresponds to reductions in total Pb emissions of 84 percent. Most (95%) of this decrease in total nationwide Pb emissions was due to the decrease in automotive Pb emissions. Even this larger group of sites was disproportionately weighted by sites in California and Pennsylvania. These States accounted for 25 percent of the 326 sites represented. However, the percent change in 1982-86 average Pb concentrations for the California and Pennsylvania sites (65 percent) and for all the other sites combined (70 percent) were very similar; thus the contributions of the California and Pennsylvania sites did not bias the national trends.

Table 3-6. National Lead Emission Estimates, 1977-1986.

(thousand metric tons/year)

Source Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Transportation	124.2	112.4	94.6	59.4	46.4	46.9	40.7	34.7	15.5	3.5
Fuel Combustion	7.2	6.1	4.9	3.9	2.8	1.7	0.6	0.5	0.5	0.5
Industrial Processes	5.7	5.4	5.2	3.6	3.0	2.7	2.4	2.3	2.3	1.9
Solid Waste	4.1	4.0	4.0	3.7	3.7	3.1	2.6	2.6	2.8	2.7
Total	141.2	127.9	108.7	70.6	55.9	54.4	46.3	40.1	21.1	8.6

NOTE: The sum of sub-categories may not equal total due to rounding.

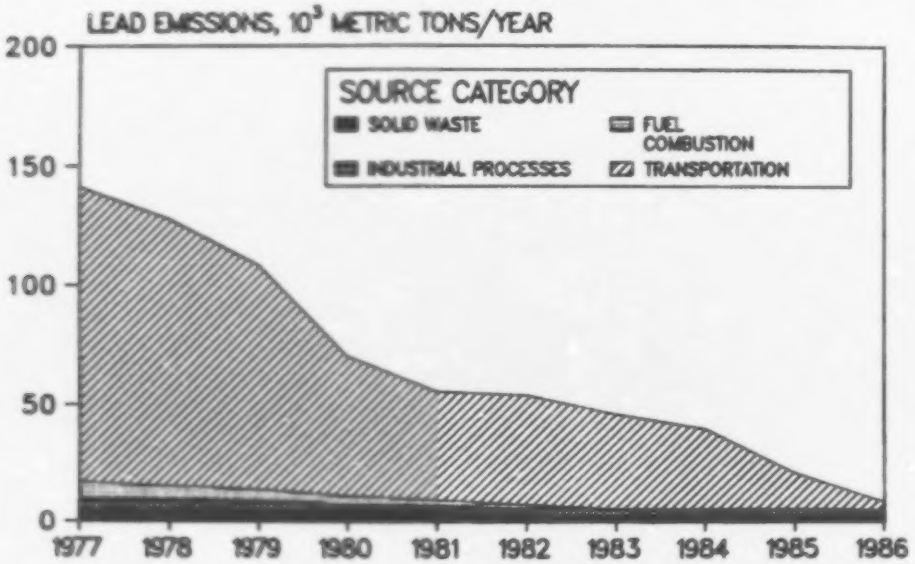

Figure 3-36. National trend in lead emissions, 1977-1986.

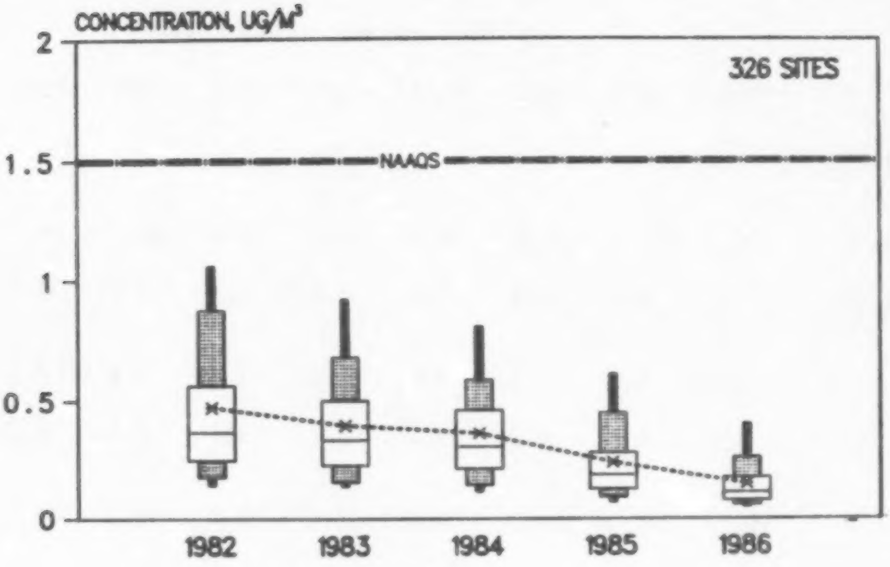

Figure 3-37. Boxplot comparisons of trends in maximum quarterly average lead concentrations at 326 sites, 1977-1986.

Figure 3-38 shows 1984, 1985 and 1986 composite average Pb concentrations by EPA region. The number of sites varies dramatically from 5 sites in Region X to 65 sites in Region IX. In all Regions except Region X, where only 5 sites were available, there is a significant difference in average Pb concentrations between 1984 and 1986. Furthermore, in five (5) of these Regions (Regions I, II, IV, V, and VIII) there was a significant decrease in average Pb concentrations between 1985 and 1986. These results confirm that average Pb concentrations in urban areas are decreasing in all sections of the country which is exactly what is to be expected because of the national air pollution control program in place for Pb.

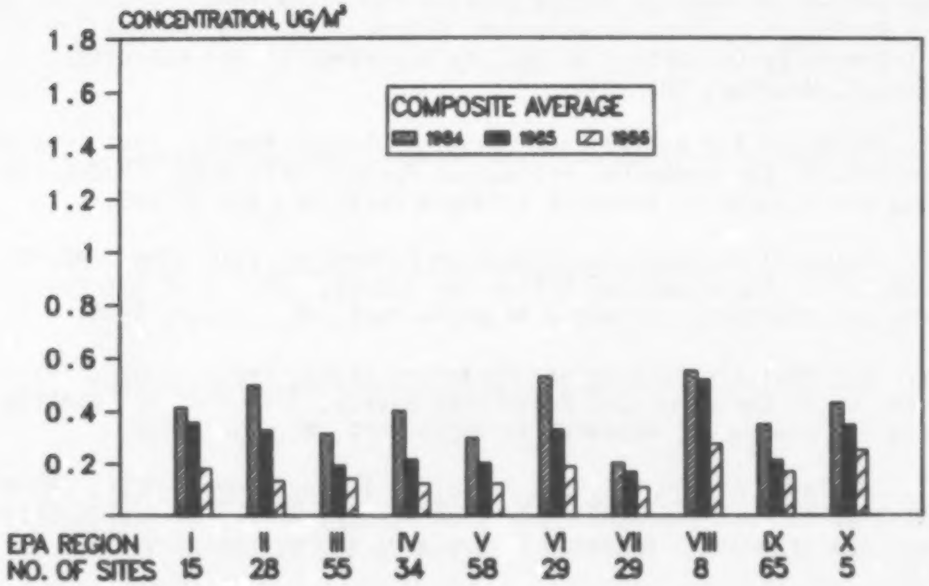

Figure 3-38. Regional comparison of the 1984, 1985, 1986 composite average of the maximum quarterly average lead concentration.

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4. AIR QUALITY LEVELS IN METROPOLITAN STATISTICAL AREAS

The Tables in this section summarize air quality levels by Metropolitan Statistical Area (MSA) for MSA's with 1984 populations greater than 500,000. These summaries are complemented with an analysis of the number of people living in counties in which pollutant specific primary health NAAQS(s) (see Table 2-1 for a complete listing) were exceeded by measured air quality in 1986 (Figure 4-1). Clearly, O_3 is the most pervasive air pollution problem in 1986 in the United States with an estimated 75 million people living in counties which exceeded the O_3 standard. TSP follows with 41.7 million people, CO with 41.4 million people, NO_2 with 7.5 million people, Pb with 4.5 million people and SO_2 with 0.9 million people. A total of 98 million persons reside in counties which exceeded at least one air quality standard during 1986.

In the MSA summary tables which follow, the air quality statistics relate to selected pollutant-specific NAAQS listed in Table 4-1. The purpose of these summaries is to provide the reader with information on how air quality varies among MSA's and from year-to-year. The highest air quality levels measured in the MSA are summarized for the years 1984, 1985 and 1986.

The reader is cautioned that these summaries are not sufficient in themselves to adequately rank or compare the MSA's according to their air quality. To properly rank the air pollution severity in different MSA(s), data on population characteristics, daily population mobility, transportation patterns, industrial composition, emission inventories, meteorological factors and, most important, the spatial representativeness of the monitoring sites would also be needed.

The same annual data completeness criterion used in the air quality trends data base was used here for the calculation of annual means. (See Section 2.1). If some data have been collected at one or more sites, but none of these sites meet the annual data completeness criteria, then the reader will be advised that there are insufficient data to calculate the annual mean.

With respect to the summary statistics for air quality levels with averaging times less than or equal to 24-hours, measured with continuous monitoring instruments, a footnote will be placed next to the level if the volume of annual data is less than 4380 hours for CO, less than 183 days for SO_2 or less than 50 percent of the days during the ozone season for ozone, which varies by State.[1] For example, in California the ozone season is defined as 12 months, January through December, while in New Jersey it is defined as 7 months, April through October.

4.1 SUMMARY STATISTICS

In the following MSA summaries, the air quality levels reported are the highest levels measured within the MSA(s). All available sites in an MSA are used in these summaries. In the case of O_3, the problem as stated

Table 4-1. Selected Air Quality Summary Statistics and Their Associated National Ambient Air Quality Standards (NAAQS)*

POLLUTANT	STATISTICS	PRIMARY NAAQS
Total Suspended Particulate	annual geometric mean	75 ug/m^3
Sulfur Dioxide	annual arithmetic mean	0.03 ppm
	second highest 24-hour average	0.14 ppm
Carbon Monoxide	second highest nonoverlapping 8-hour average	9 ppm
Nitrogen Dioxide	annual arithmetic mean	0.053 ppm
Ozone	second highest daily maximum 1-hour average	0.12 ppm
Lead	maximum quarterly average	1.5 ug/m^3

ug/m^3 = micrograms per cubic meter
ppm = parts per million

*for a detailed listing of the NAAQS see Table 2-1.

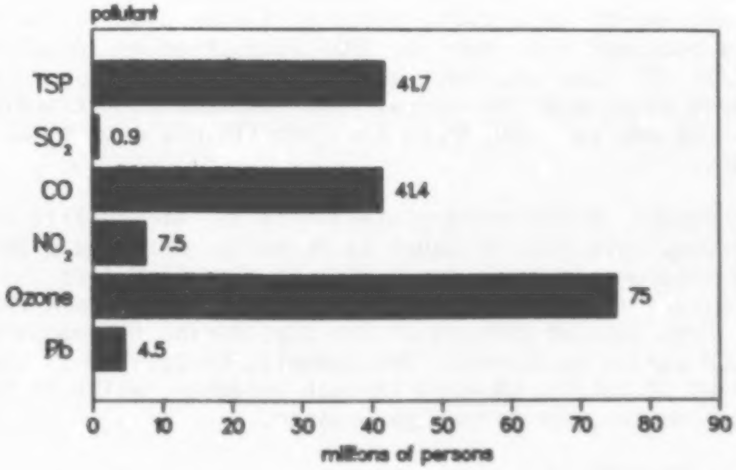

Figure 4-1. Number of persons living in counties with air quality levels above the primary national ambient air quality standards in 1986 (based on 1980 population data).

earlier is pervasive and the high values associated with the pollutant can reflect a large part of the MSA. However, in many cases peak ozone concentrations occur downwind of major urban areas, e.g. peak ozone levels attributed to the Chicago metropolitan area are recorded in and near Racine, Wisconsin. In contrast, high CO values are generally highly localized and reflect downtown areas with heavy traffic. The scale of measurement for the pollutants - TSP, SO_2 and NO_2 - fall somewhere in between. Finally, while Pb measurements generally reflect Pb concentrations near roadways in the MSA, if the monitor is located near a point source of lead emissions it can produce readings substantially higher. Such is the case in several MSAs. If the Pb monitor is located near a point source it will be footnoted accordingly in Table 4-8.

The pollutant-specific statistics reported in this section are summarized in Table 4-1, along with their associated primary NAAQS concentrations for a single year of data. For example, if an MSA has three ozone monitors in 1986 with second highest daily hourly maxima of .15 ppm, .14 ppm and .12 ppm, the highest of these, .15 ppm, would be reported for that MSA for 1986.

In the case of Pb, the quarterly average is based either on as many as 90 24-hour measurements or one or more chemical composite measurements.* Most of the maximum quarterly Pb averages are based on multiple 24-hour measurements. If the maximum quarterly average is based on a chemical composite, it is footnoted accordingly.

4.2 AIR QUALITY MSA COMPARISONS

In each of the following MSA air quality summaries, the MSA's are grouped according to population starting with the largest MSA - New York, NY-NJ and continuing to the smallest MSA with a population in excess of 500,000, New Haven-Meriden, Connecticut. The population groupings and the number of MSA's contained within each are as follows: 17 MSA's have populations in excess of 2 million, 27 MSA's have populations between 1 and 2 million and 45 MSA's have populations between 0.5 and 1 million. The population statistics are based on the 1984 Metropolitan Statistical Areas estimates.[2]

Air quality maps of the United States are introduced to show at a glance how air quality varies among the largest MSAs within the contiguous United States. Figures 4-2 through 4-7 appear just before the appropriate table summarizing the same air pollution specific statistic. In each map, a spike is plotted at the city location on the map surface. This represents the highest pollutant concentration, recorded in 1986, corresponding to the appropriate air quality standard. Each spike is also projected onto a backdrop facilitating comparison with the level of the standard. This also provides an east-west profile of concentration variability throughout the country.

The air quality summary statistics are summarized in the following figures and tables:

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*A chemical composite measurement can be either a measurement for an entire month or an entire quarter.

Figure 4-2. United States Map of the Highest Annual Geometric Mean Suspended Particulate Concentration by MSA, 1986. The map for particulate matter displays the maximum annual geometric mean TSP concentration in 1986 for large metropolitan areas. The highest concentrations are generally found in the industrial Midwest and arid areas of the West. The east-west profile shows that levels above the current standard of 75 ug/m^3 can be found throughout the Nation.

Table 4-2. Highest Annual Geometric Mean Suspended Particulate Concentration by MSA, 1984-86.

Figure 4-3. United States Map of the Highest Annual Arithmetic Mean Sulfur Dioxide Concentration by MSA, 1986. The map for sulfur dioxide shows maximum annual mean concentrations in 1986. Among these large metropolitan areas, the higher concentrations are found in the heavily populated Midwest and Northeast. All urban areas have ambient air quality concentrations lower than the current annual standard of 80 ug/m^3 (.03 ppm). Because this map only represents areas with population greater than one half million, it does not reflect air quality in the vicinity of smelters or large power plants in rural areas.

Table 4-3. Highest Annual Arithmetic Mean Sulfur Dioxide Concentration by MSA, 1984-86.

Figure 4-4. United States Map of the Highest Second Maximum 24-hour Average Sulfur Dioxide Concentration by MSA, 1986. The map for sulfur dioxide shows the highest second highest maximum 24-hour average sulfur dioxide concentration by MSA in 1986. The highest urban concentration is found at a site in Memphis, TN impacted by several SO_2 sources. All other urban areas have lower ambient concentrations below the 24-hour NAAQS of 0.14 parts per million.

Table 4-4. Highest Second Maximum 24-hour Average Sulfur Dioxide Concentration by MSA, 1984-86.

Figure 4-5. United States Map of the Highest Second Maximum Nonoverlapping 8-hour Average Carbon Monoxide Concentration by MSA, 1986. The map for carbon monoxide shows peak metropolitan concentrations in terms of the second highest annual 8-hour value recorded in 1986. The east-west profile indicates that many of these urban areas in all geographic regions have air quality at or exceeding the 9 ppm level of the standard. The highest concentration recorded in 1986 is found in Denver, CO while Los Angeles, CA recorded the second highest concentration.

Table 4-5. Highest Second Maximum Nonoverlapping 8-hour Average Carbon Monoxide Concentration by MSA, 1984-86.

Figure 4-6. United States Map of the Highest Annual Arithmetic Mean Nitrogen Dioxide Concentration by MSA, 1986. The map for nitrogen dioxide displays the maximum annual mean measured in the Nation's largest metropolitan areas during 1986. Los Angeles, California, with an annual NO_2 mean of 0.061 ppm is the only area in the country exceeding the NO_2 air quality standard of .053 ppm.

Table 4-6. Highest Annual Arithmetic Mean Nitrogen Dioxide Concentration by MSA, 1984-86.

Figure 4-7. United States Map of the Highest Second Daily Maximum 1-hour Average Ozone Concentrations by MSA, 1986. The ozone map shows the second highest daily maximum concentration in the 89 largest metropolitan areas. As shown, about half of these areas did not meet the 0.12 ppm standard in 1986. The highest concentrations are observed in Southern California, but high levels also persist in the Texas Gulf Coast, Northeast Corridor, and other heavily populated regions.

Table 4-7. Highest Second Daily Maximum 1-hour Average Ozone Concentration by MSA, 1984-86.

Figure 4-8. United States Map of the Highest Maximum Quarterly Average Lead Concentration by MSA, 1986. The map for Pb displays maximum quarterly average concentrations in the Nation's largest metropolitan areas. The highest concentrations are found throughout the country in cities containing nonferrous smelters or other point sources of lead. Because of the switch to unleaded gasoline, other areas, primarily affected by automotive lead emissions, show levels below the current standard of 1.5 ug/m^3.

Table 4-8. Highest Maximum Quarterly Average Lead Concentration by MSA, 1984-86.

The air quality summaries follow:

4.3 REFERENCES

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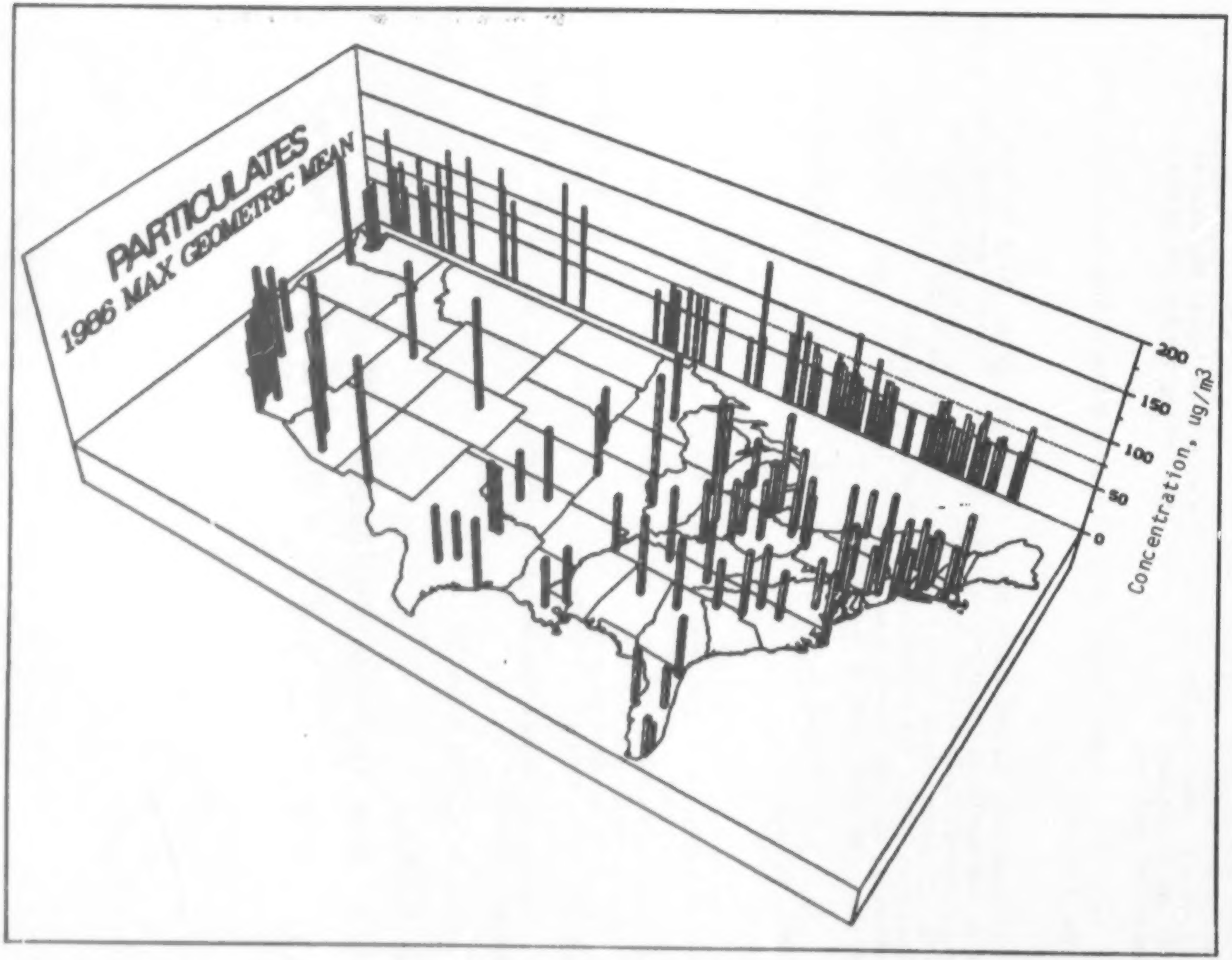
PARTICULATES
1986 MAX GEOMETRIC MEAN
200
150
100
50
0
Concentration, ug/m3

Figure 4-2 United States map of the highest annual geometric mean suspended particulate concentration by MSA, 1986.

Table 4-2. Highest Annual Geometric Mean Suspended Particulate Concentration by MSA, 1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 1

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST ANNUAL GEOMETRIC MEAN 1984	1985	1986
POPULATION: > 2 MILLION			
NEW YORK, NY	64	70	61
LOS ANGELES-LONG BEACH, CA	108	104	101
CHICAGO, IL	85	85	97
PHILADELPHIA, PA-NJ	73	63	61
DETROIT, MI	106	107	103
WASHINGTON, DC-MD-VA	70	67	70
HOUSTON, TX	94	81	74
BOSTON, MA	58	81	82
NASSAU-SUFFOLK, NY	49	48	48
ST. LOUIS, MO-IL	119	120	137
ATLANTA, GA	72	60	74
MINNEAPOLIS-ST. PAUL, MN-WI	75	73	71
BALTIMORE, MD	88	78	72

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL GEOMETRIC MEAN

TABLE 4-2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 2

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST ANNUAL GEOMETRIC MEAN		
	1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	70	68	69
PITTSBURGH, PA	83	78	55
ANAHEIM-SANTA ANA, CA	97	91	89
SAN DIEGO, CA	74	79	77

TOTAL MSA'S > 2 MILLION : 17

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
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Table 4-2

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SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST ANNUAL GEOMETRIC MEAN 1984	1985	1986
POPULATION: 1 - 2 MILLION			
NEWARK, NJ	73	81	63
OAKLAND, CA	57	58	48
CLEVELAND, OH	116	95	86
RIVERSIDE-SAN BERNARDINO, CA	133	132	120
TAMPA-ST. PETERSBURG-CLEARWATER, FL	68	64	59
PHOENIX, AZ	126	115	123
MIAMI-HIALEAH, FL	50	73	42
SEATTLE, WA	68	77	73
DENVER, CO	142	144	118
SAN FRANCISCO, CA	60	62	52
SAN JUAN, PR	77	82	71
KANSAS CITY, MO-KS	69	70	74
CINCINNATI, OH-KY-IN	70	64	64

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
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SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST 1984	ANNUAL GEOMETRIC MEAN 1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	58	57	73
SAN JOSE, CA	79	90	84
NEW ORLEANS, LA	64	61	59
BERGEN-PASSAIC, NJ	54	52	45
COLUMBUS, OH	72	63	62
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	57	53	58
SACRAMENTO, CA	65	66	56
INDIANAPOLIS, IN	69	76	74
SAN ANTONIO, TX	66	67	60
FORT WORTH-ARLINGTON, TX	74	70	73
PORTLAND, OR-WA	80	97	116
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	48	43	29
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	67	56	68

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
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SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 5

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST 198[illegible]	ANNUAL GEOMETRIC MEAN 1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	100	97	104
TOTAL MSA'S 1 - 2 MILLION : 27			

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
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Table 4-2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 6

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST ANNUAL GEOMETRIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION			
ROCHESTER, NY	50	43	49
BUFFALO, NY	54	50	48
OKLAHOMA CITY, OK	60	61	52
LOUISVILLE, KY-IN	82	66	65
MEMPHIS, TN-AR-MS	70	55	59
DAYTON-SPRINGFIELD, OH	59	60	67
MIDDLESEX-SOMERSET-HUNTERDON, NJ	59	68	79
MONMOUTH-OCEAN, NJ	45	42	42
BIRMINGHAM, AL	98	85	83
NASHVILLE, TN	69	66	78
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	57	57	65
ALBANY-SCHENECTADY-TROY, NY	60	59	53
ORLANDO, FL	48	43	43

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
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Table 4-2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST 1984	ANNUAL GEOMETRIC MEAN 1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	48	52	31
RICHMOND-PETERSBURG, VA	51	47	52
JACKSONVILLE, FL	62	57	63
HARTFORD, CT	48	60	61
SCRANTON-WILKES-BARRE, PA	55	51	47
TULSA, OK	72	81	77
WEST PALM BEACH-BOCA RATON-DELRAY BEACH FL	43	37	ND
SYRACUSE, NY	68	61	57
AKRON, OH	55	50	51
ALLENTOWN-BETHLEHEM, PA-NJ	74	70	68
AUSTIN, TX	51	49	49
GARY-HAMMOND, IN	88	112	91
GRAND RAPIDS, MI	52	44	51

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL GEOMETRIC MEAN

Table 4-2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST ANNUAL GEOMETRIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	53	61	53
TOLEDO, OH	60	55	59
RALEIGH-DURHAM, NC	48	47	50
OMAHA, NE-IA	74	65	59
TUCSON, AZ	92	102	92
GREENVILLE-SPARTANBURG, SC	51	43	51
KNOXVILLE, TN	62	57	64
OXNARD-VENTURA, CA	77	69	68
HARRISBURG-LEBANON-CARLISLE, PA	59	49	48
FRESNO, CA	103	108	96
JERSEY CITY, NJ	79	81	66
WILMINGTON, DE-NJ-MD	46	47	50
BATON ROUGE, LA	54	49	52

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
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Table 4-2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SUSPENDED PARTICULATE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 9

METROPOLITAN STATISTICAL AREA	SUSPENDED PARTICULATE CONCENTRATION (UG/M3) HIGHEST ANNUAL GEOMETRIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	101	113	121
EL PASO, TX	122	127	134
YOUNGSTOWN-WARREN, OH	64	66	68
TACOMA, WA	69	83	68
SPRINGFIELD, MA	49	54	53
NEW HAVEN-MERIDEN, CT	45	49	58

TOTAL MSA'S .5 - 1 MILLION : 45

NOTE: THE ANNUAL GEOMETRIC MEAN IS CALCULATED IF THE DATA COLLECTED SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL GEOMETRIC MEAN

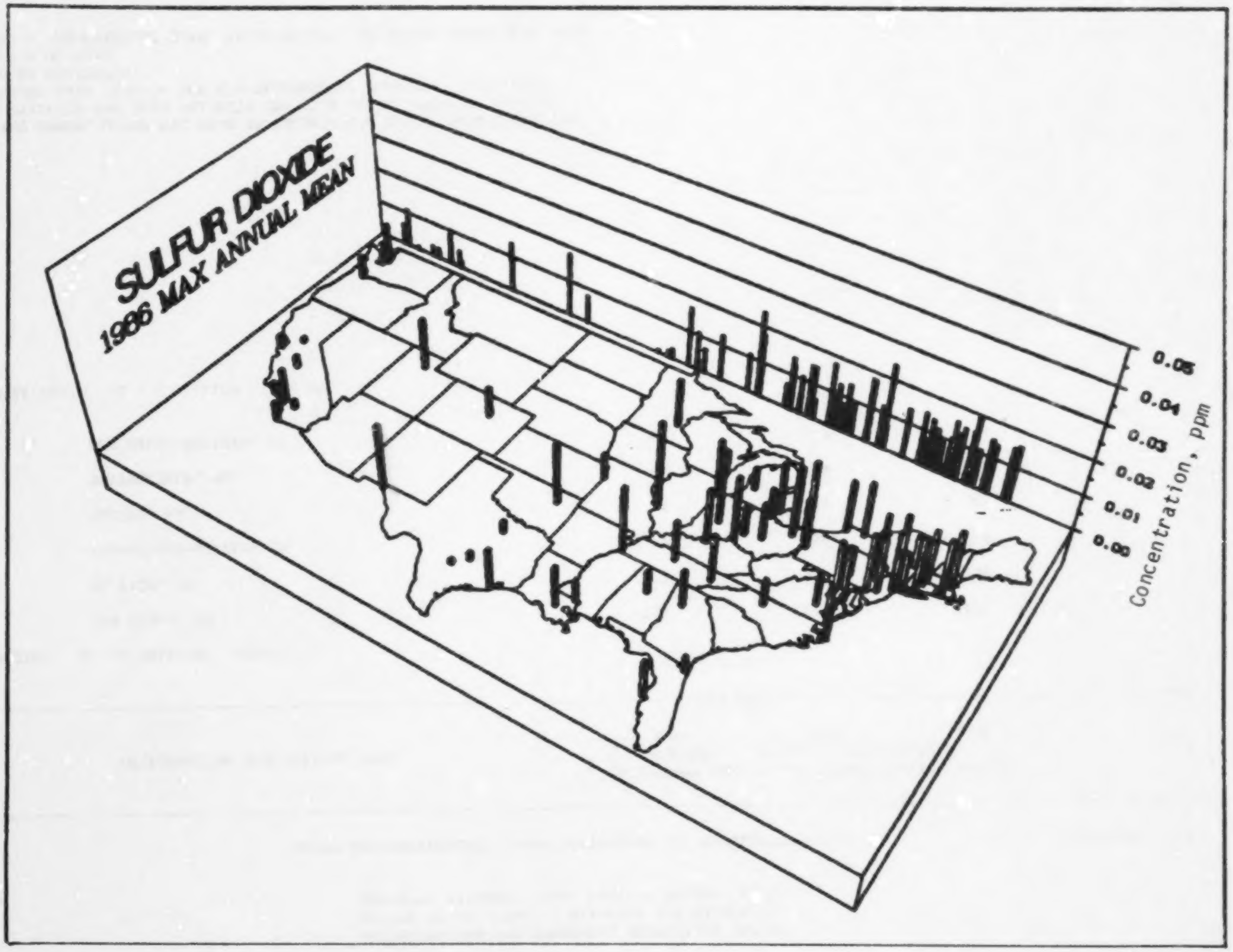
SULFUR DIOXIDE
1986 MAX ANNUAL MEAN
0.05
0.04
0.03
0.02
0.01
0.00
Concentration, ppm

Figure 4-3 United States map of the highest annual arithmetic mean sulfur dioxide concentration by MSA, 1986.

Table 4-3. Highest Annual Arithmetic Mean Sulfur Dioxide Concentration by MSA, 1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 1

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: > 2 MILLION			
NEW YORK, NY	.024	.022	.020
LOS ANGELES-LONG BEACH, CA	.011	.008	.009
CHICAGO, IL	.017	.019	.015
PHILADELPHIA, PA-NJ	.019	.017	.015
DETROIT, MI	.014	.014	.014
WASHINGTON, DC-MD-VA	.014	.013	.014
HOUSTON, TX	.010	.008	.011
BOSTON, MA	.016	.013	.016
NASSAU-SUFFOLK, NY	.013	.011	.011
ST. LOUIS, MO-IL	.021	.020	.024
ATLANTA, GA	.009	.009	.010
MINNEAPOLIS-ST. PAUL, MN-WI	.012	.013	.013
BALTIMORE, MD	.015	.012	.012

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.

ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 2

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	.005	.004	IN
PITTSBURGH, PA	.044	.028	.024
ANAHEIM-SANTA ANA, CA	.007	.006	.006
SAN DIEGO, CA	.005	.006	.005
TOTAL MSA'S > 2 MILLION : 17			

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.

ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 3

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: 1 - 2 MILLION			
NEWARK, NJ	.015	.016	.015
OAKLAND, CA	.002	.002	.002
CLEVELAND, OH	.022	.019	.018
RIVERSIDE-SAN BERNARDINO, CA	.003	.003	.002
TAMPA-ST. PETERSBURG-CLEARWATER, FL	.006	.008	.010
PHOENIX, AZ	IN	IN	IN
MIAMI-HIALEAH, FL	IN	IN	ND
SEATTLE, WA	.011	.011	.011
DENVER, CO	.011	.008	.008
SAN FRANCISCO, CA	.005	.003	.003
SAN JUAN, PR	ND	ND	ND
KANSAS CITY, MO-KS	.014	.008	.007
CINCINNATI, OH-KY-IN	.025	.027	.018

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.

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Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 4

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	.009	.007	.007
SAN JOSE, CA	ND	ND	ND
NEW ORLEANS, LA	.006	.006	.005
BERGEN-PASSAIC, NJ	.016	.015	.015
COLUMBUS, OH	.017	.014	.010
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	.010	.010	.010
SACRAMENTO, CA	.002	.002	.001
INDIANAPOLIS, IN	.017	.019	.015
SAN ANTONIO, TX	.002	.003	.001
FORT WORTH-ARLINGTON, TX	.003	.005	.003
PORTLAND, OR-WA	.007	IN	.006
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	ND	ND	ND
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	.014	.005	ND

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
3 = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE   CONCENTRATION BY MSA POPULATION RANGE   PAGE NO: 5

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	 1985	 1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	.014	.014	.014
TOTAL MSA'S 1 - 2 MILLION : 27			

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 6

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION			
ROCHESTER, NY	.015	.014	.015
BUFFALO, NY	.016	.015	.014
OKLAHOMA CITY, OK	IN	.006	IN
LOUISVILLE, KY-IN	.015	.013	.015
MEMPHIS, TN-AR-MS	.013	.008	.018
DAYTON-SPRINGFIELD, OH	.010	.009	.008
MIDDLESEX-SOMERSET-HUNTERDON, NJ	.016	.011	.011
MONMOUTH-OCEAN, NJ	ND	ND	ND
BIRMINGHAM, AL	ND	.005	.006
NASHVILLE, TN	.011	.011	.011
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	.008	.007	.007
ALBANY-SCHENECTADY-TROY, NY	.014	.010	.009
ORLANDO, FL	.002	.002	ND

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
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IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 7

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	.006	.006	.001 B
RICHMOND-PETERSBURG, VA	.008	.007	.008
JACKSONVILLE, FL	.007	.008	.004
HARTFORD, CT	.012	.009	.013
SCRANTON-WILKES-BARRE, PA	.012	.012	.011
TULSA, OK	.019	.025	.017
WEST PALM BEACH-BOCA RATON-DELRAY BEACH, FL	.003	.002	ND
SYRACUSE, NY	.013	.019	.009
AKRON, OH	.017	.021	.018
ALLENTOWN-BETHLEHEM, PA-NJ	.015	.011	.013
AUSTIN, TX	.003	.001	.002
GARY-HAMMOND, IN	.016	.018	.013
GRAND RAPIDS, MI	.005	.007	.006

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.

ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	.013	.013	.015
TOLEDO, OH	.010	.009	.008
RALEIGH-DURHAM, NC	ND	ND	ND
OMAHA, NE-IA	.003	IN	IN
TUCSON, AZ	.010	.006	IN
GREENVILLE-SPARTANBURG, SC	IN	.003	IN
KNOXVILLE, TN	.007	.008	.013
OXNARD-VENTURA, CA	.002	IN	.003
HARRISBURG-LEBANON-CARLISLE, PA	.010	.009	.008
FRESNO, CA	.003	.003	.003
JERSEY CITY, NJ	.016	.015	.014
WILMINGTON, DE-NJ-MD	.018	.014	.016
BATON ROUGE, LA	.008	.013	.011

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-3

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	 1985	 1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	ND	ND	ND
EL PASO, TX	.025	.022	.018
YOUNGSTOWN-WARREN, OH	.011	.011	.012
TACOMA, WA	.011	.010	.006
SPRINGFIELD, MA	.012	.012	.014
NEW HAVEN-MERIDEN, CT	.013	.017	.015

TOTAL MSA'S .5 - 1 MILLION : 45

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

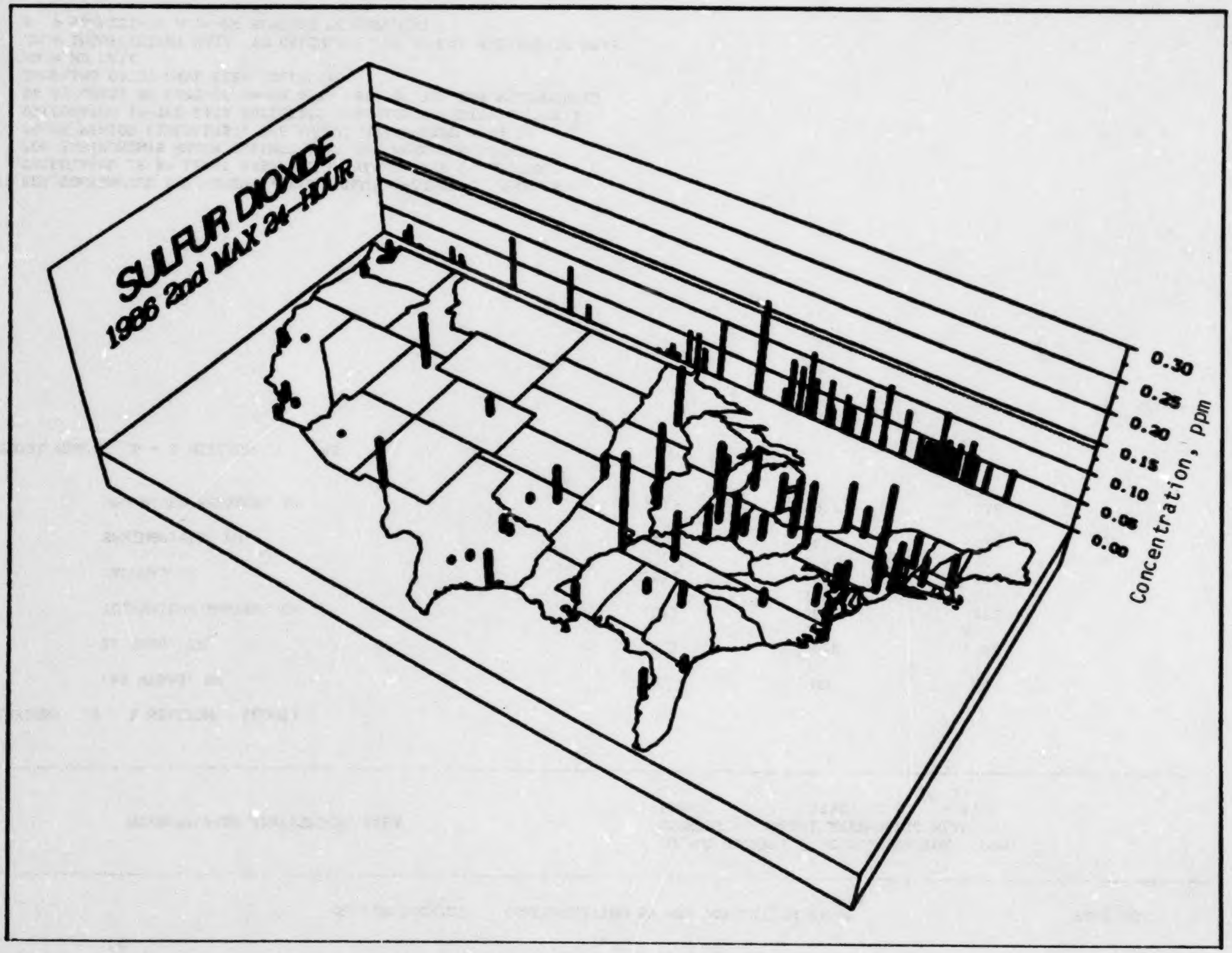
SULFUR DIOXIDE
1986 2nd MAX 24-HOUR
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Concentration, ppm

Figure 4-4 United States map of the highest second maximum 24-hour average sulfur dioxide concentration by MSA, 1986.

Table 4-4. Highest Second Maximum 24-Hour Average Sulfur Dioxide Concentration by MSA,1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 1

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: > 2 MILLION			
NEW YORK, NY	.084	.063	.073
LOS ANGELES-LONG BEACH, CA	.035	.029	.026
CHICAGO, IL	.089	.105	.084
PHILADELPHIA, PA-NJ	.076	.067	.061
DETROIT, MI	.063	.056	.063
WASHINGTON, DC-MD-VA	.045	.042	.043
HOUSTON, TX	.065	.039	.061
BOSTON, MA	.073	.049	.054
NASSAU-SUFFOLK, NY	.075	.047	.051
ST. LOUIS, MO-IL	.136	.103	.138
ATLANTA, GA	.028	.038	.037
MINNEAPOLIS-ST. PAUL, MN-WI	.087	.101	.097
BALTIMORE, MD	.050	.035	.044

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 2

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	.018	.016	.012 *
PITTSBURGH, PA	.268	.168	.108
ANAHEIM-SANTA ANA, CA	.016	.016	.015
SAN DIEGO, CA	.021	.021	.019
TOTAL MSA'S > 2 MILLION : 17			

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 3

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE HIGHEST 1984	CONCENTRATION 2ND MAX 24-HR AVG. 1985	(PPM) 1986
POPULATION: 1 - 2 MILLION			
NEWARK, NJ	.061	.047	.047
OAKLAND, CA	.021	.014	.015
CLEVELAND, OH	.106	.079	.087
RIVERSIDE-SAN BERNARDINO, CA	.010	.008	.010
TAMPA-ST. PETERSBURG-CLEARWATER, FL	.036	.041	.043
PHOENIX, AZ	.013 *	.017 *	.003 *
MIAMI-HIALEAH, FL	.006 *	.004 *	ND
SEATTLE, WA	.045	.028	.033
DENVER, CO	.035	.023	.028
SAN FRANCISCO, CA	.033	.026	.024
SAN JUAN, PR	ND	ND	ND
KANSAS CITY, MO-KS	.042	.039 *	.039
CINCINNATI, OH-KY-IN	.078	.087	.076

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 4

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	.060	.046	.030
SAN JOSE, CA	ND	ND	ND
NEW ORLEANS, LA	.027	.036	.028
BERGEN-PASSAIC, NJ	.063	.049	.053
COLUMBUS, OH	.083	.059	.039
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	.031	.037	.034
SACRAMENTO, CA	.010	.009	.005
INDIANAPOLIS, IN	.077	.129	.110
SAN ANTONIO, TX	.010	.010	.005
FORT WORTH-ARLINGTON, TX	.047	.031	.024
PORTLAND, OR-WA	.027	.025 *	.019
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	ND	ND	ND
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	.035	.032	ND

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 5

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	.073	.067	.090
TOTAL MSA'S 1 - 2 MILLION : 27			

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 6

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION			
ROCHESTER, NY	.052	.050	.047
BUFFALO, NY	.075	.076	.080
OKLAHOMA CITY, OK	.024 *	.018	.010 *
LOUISVILLE, KY-IN	.082	.062	.062
MEMPHIS, TN-AR-MS	.067	.079 *	.161 **
DAYTON-SPRINGFIELD, OH	.044	.049	.030
MIDDLESEX-SOMERSET-HUNTERDON, NJ	.075	.048	.041
MONMOUTH-OCEAN, NJ	ND	ND	ND
BIRMINGHAM, AL	ND	.023	.019
NASHVILLE, TN	.088	.074	.079
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	.025	.024	.023 *
ALBANY-SCHENECTADY-TROY, NY	.060	.035	.053 *
ORLANDO, FL	.014	.012	ND

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
** THIS LEVEL REFLECTS THE IMPACT OF AN INDUSTRIAL SOURCE WITH A PENDING ENFORCEMENT ACTION. THE NEXT HIGHEST 24-HOUR CONCENTRATION IS 0.082 PPM.
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 7

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	.025	.034	.003 *
RICHMOND-PETERSBURG, VA	.041	.026	.031
JACKSONVILLE, FL	.052	.068	.022
HARTFORD, CT	.081	.039	.044
SCRANTON-WILKES-BARRE, PA	.065	.047	.060
TULSA, OK	.057	.080	.059
WEST PALM BEACH-BOCA RATON-DELRAY BEACH, FL	.014	.009	ND
SYRACUSE, NY	.121	.285 **	.102
AKRON, OH	.062	.081	.059
ALLENTOWN-BETHLEHEM, PA-NJ	.064	.046 *	.047
AUSTIN, TX	.010	.019	.010
GARY-HAMMOND, IN	.106	.131	.080 *
GRAND RAPIDS, MI	.026	.063 *	.069

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
** THIS LEVEL REFLECTS THE IMPACT OF AN INDUSTRIAL SOURCE THAT CEASED OPERATION IN 1986.
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	.068	.047	.048 *
TOLEDO, OH	.038	.099	.048
RALEIGH-DURHAM, NC	ND	ND	ND
OMAHA, NE-IA	.012	.006 *	.002 *
TUCSON, AZ	.082	.079 *	.008 *
GREENVILLE-SPARTANBURG, SC	.013 *	.018	.022 *
KNOXVILLE, TN	.034	.058	.062
OXNARD-VENTURA, CA	.010	.008	.011
HARRISBURG-LEBANON-CARLISLE, PA	.047	.033	.038
FRESNO, CA	.016	.012	.014
JERSEY CITY, NJ	.058	.051	.047
WILMINGTON, DE-NJ-MD	.062	.053	.047
BATON ROUGE, LA	.042	.073	.040

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

SULFUR DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	SULFUR DIOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 24-HR AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	ND	ND	ND
EL PASO, TX	.097	.085	.082
YOUNGSTOWN-WARREN, OH	.052	.050	.048
TACOMA, WA	.035	.034	.015
SPRINGFIELD, MA	.068	.054	.058
NEW HAVEN-MERIDEN, CT	.090	.069	.062

TOTAL MSA'S .5 - 1 MILLION : 45

NOTE: THE 24-HR AVERAGE IS CALCULATED BASED ON THE MIDNIGHT TO MIDNIGHT PERIOD.
* LESS THAN 183 DAYS OF DATA
ND = NO DATA
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

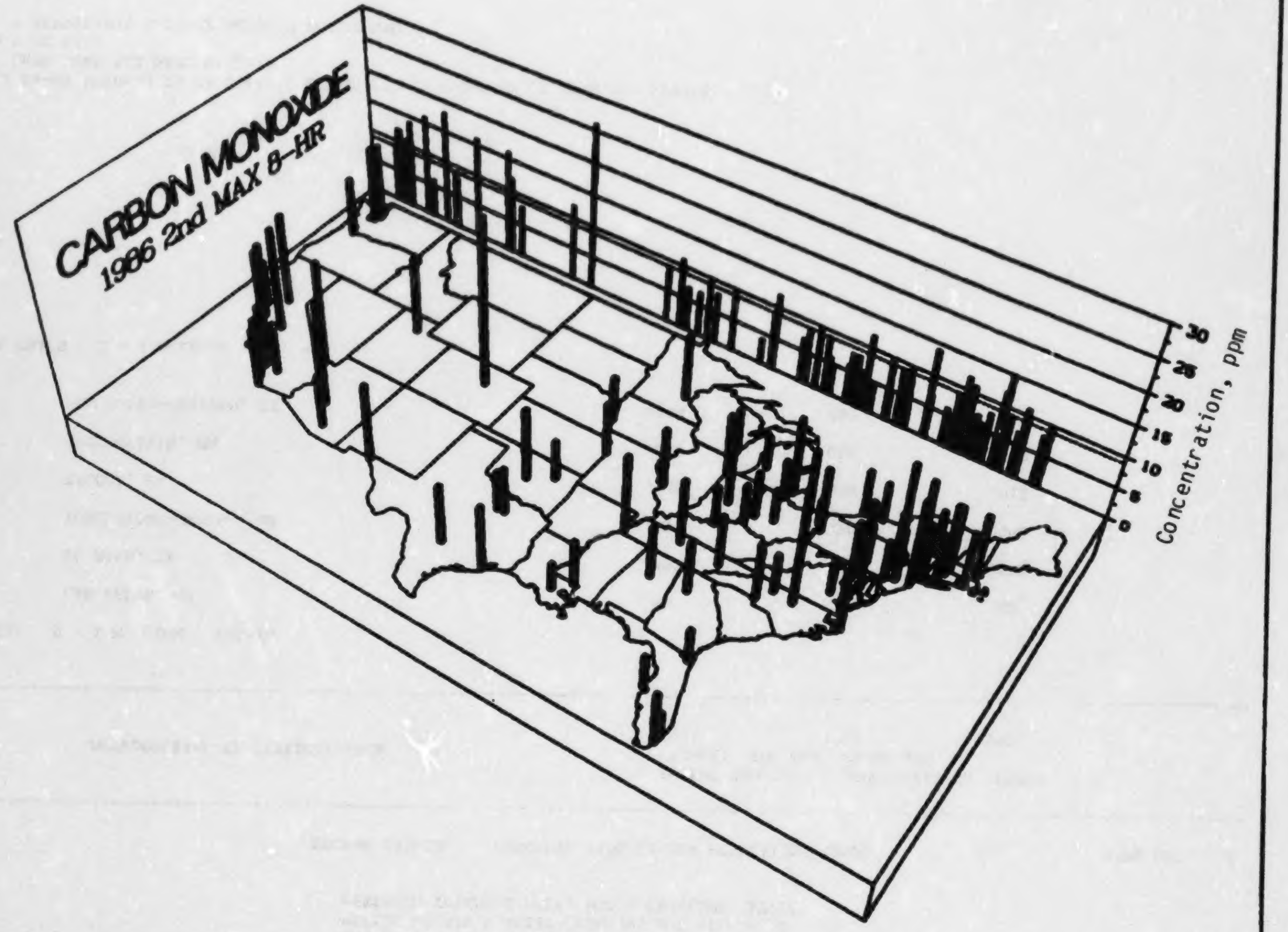
CARBON MONOXIDE
1986 2nd MAX 8-HR
Concentration, ppm
30
25
20
15
10
5
0

Figure 4-5 United States map of the highest second maximum non-overlapping 8-hour average carbon monoxide concentration by MSA, 1986.

Table 4-5. Highest Second Maximum Nonoverlapping 8-Hour Average Carbon Monoxide Concentration by MSA, 1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 1

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE HIGHEST 1984	CONCENTRATION 2ND MAX 8-HR N/O AVG. 1985	(PPM) 1986
POPULATION: > 2 MILLION			
NEW YORK, NY	15	16	15
LOS ANGELES-LONG BEACH, CA	19	27	18
CHICAGO, IL	11	8	9
PHILADELPHIA, PA-NJ	10	8	8
DETROIT, MI	11	8	12
WASHINGTON, DC-MD-VA	14	10	9
HOUSTON, TX	7	8	10
BOSTON, MA	10	8	10
NASSAU-SUFFOLK, NY	10	8	9
ST. LOUIS, MO-IL	7	8	9
ATLANTA, GA	11	9	8
MINNEAPOLIS-ST. PAUL, MN-WI	13	13	10
BALTIMORE, MD	14	10	12

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
● ND = NO DATA

Table 4-5. Highest Second Maximum Nonoverlapping 8-Hour Average Carbon Monoxide Concentration by MSA, 1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 1

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: > 2 MILLION			
NEW YORK, NY	15	16	15
LOS ANGELES-LONG BEACH, CA	19	27	18
CHICAGO, IL	11	8	9
PHILADELPHIA, PA-NJ	10	8	8
DETROIT, MI	11	8	12
WASHINGTON, DC-MD-VA	14	10	9
HOUSTON, TX	7	8	10
BOSTON, MA	10	8	10
NASSAU-SUFFOLK, NY	10	8	9
ST. LOUIS, MO-IL	7	8	9
ATLANTA, GA	11	9	8
MINNEAPOLIS-ST. PAUL, MN-WI	13	13	10
BALTIMORE, MD	14	10	12

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 2

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	7	10	7
PITTSBURGH, PA	10	9	10
ANAHEIM-SANTA ANA, CA	10	13	10
SAN DIEGO, CA	8	10	9

TOTAL MSA'S > 2 MILLION : 17

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE   CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE HIGHEST 2ND MAX 1984	CONCENTRATION 8-HR N/O AVG. 1985	(PPM) 1986
POPULATION: 1 - 2 MILLION			
NEWARK, NJ	18	11	12
OAKLAND, CA	7	6	7
CLEVELAND, OH	7	8	10 *
RIVERSIDE-SAN BERNARDINO, CA	7	8	8
TAMPA-ST. PETERSBURG-CLEARWATER, FL	7	7	5
PHOENIX, AZ	17	15	16 *
MIAMI-HIALEAH, FL	10 *	10	8
SEATTLE, WA	10	11	12
DENVER, CO	20	21	26
SAN FRANCISCO, CA	8	12	10
SAN JUAN, PR	7	7	7
KANSAS CITY, MO-KS	13	6	8
CINCINNATI, OH-KY-IN	7	7	6

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 4

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	12	5	7
SAN JOSE, CA	10	14	11
NEW ORLEANS, LA	9	9	7
BERGEN-PASSAIC, NJ	11	7	10
COLUMBUS, OH	8	6	5
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	11	8	6
SACRAMENTO, CA	14	16	14
INDIANAPOLIS, IN	9	8	9
SAN ANTONIO, TX	8	7	9
FORT WORTH-ARLINGTON, TX	6	6	6
PORTLAND, OR-WA	10	9	9
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	8	7	4
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	13	11	9

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	11	11	12
TOTAL MSA'S 1 - 2 MILLION : 27			

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE   CONCENTRATION BY MSA POPULATION RANGE   PAGE NO: 6

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION			
ROCHESTER, NY	5	4	6
BUFFALO, NY	5	5	7
OKLAHOMA CITY, OK	13	11	11
LOUISVILLE, KY-IN	12	8	6
MEMPHIS, TN-AR-MS	10 *	9	12
DAYTON-SPRINGFIELD, OH	7	5	7
MIDDLESEX-SOMERSET-HUNTERDON, NJ	8	7	6
MONMOUTH-OCEAN, NJ	8	8	7
BIRMINGHAM, AL	10	7	8
NASHVILLE, TN	10 *	10	10
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	11	7	6
ALBANY-SCHENECTADY-TROY, NY	7	6	7
ORLANDO, FL	7	6 *	ND

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 7

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	6	6	4
RICHMOND-PETERSBURG, VA	7	4	5
JACKSONVILLE, FL	8	7	5
HARTFORD, CT	12	12	11
SCRANTON-WILKES-BARRE, PA	7	4	7
TULSA, OK	7	4	6
WEST PALM BEACH-BOCA RATON-DELRAY BEACH, FL	4	3	ND
SYRACUSE, NY	12	15	11
AKRON, OH	5	5	5
ALLENTOWN-BETHLEHEM, PA-NJ	8	7	6
AUSTIN, TX	ND	ND	ND
GARY-HAMMOND, IN	6	6	5
GRAND RAPIDS, MI	5 *	7	5

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 8

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	11	10	8
TOLEDO, OH	11	6	6
RALEIGH-DURHAM, NC	17	13	14
OMAHA, NE-IA	8	5 *	7 *
TUCSON, AZ	10	9	8 *
GREENVILLE-SPARTANBURG, SC	ND	ND	ND
KNOXVILLE, TN	9	9	8
OXNARD-VENTURA, CA	5	6	6
HARRISBURG-LEBANON-CARLISLE, PA	7	6 *	6
FRESNO, CA	11	11	15
JERSEY CITY, NJ	14	11	10
WILMINGTON, DE-NJ-MD	8	7	6
BATON ROUGE, LA	3	5	4

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

CARBON MONOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	CARBON MONOXIDE CONCENTRATION (PPM) HIGHEST 2ND MAX 8-HR N/O AVG. 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	16 *	15	16
EL PASO, TX	13 *	13	12
YOUNGSTOWN-WARREN, OH	5	5	4
TACOMA, WA	10	12	12
SPRINGFIELD, MA	10	7	10
NEW HAVEN-MERIDEN, CT	6 *	7	7

TOTAL MSA'S .5 - 1 MILLION : 45

NOTE: N/O NON-OVERLAPPING
* LESS THAN 4380 HOURLY VALUES OF DATA
ND = NO DATA

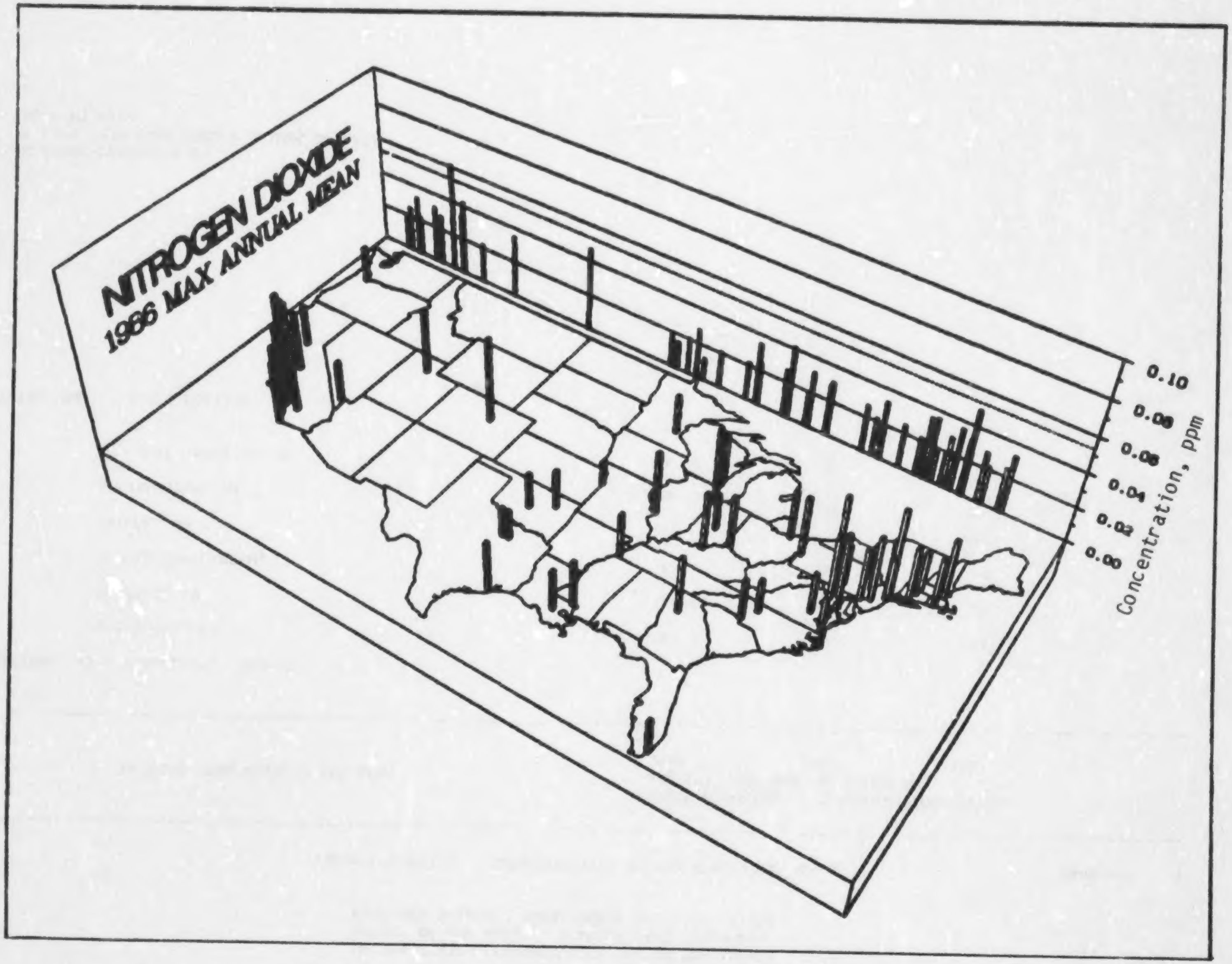
NITROGEN DIOXIDE
1986 MAX ANNUAL MEAN
0.10
0.08
0.06
0.04
0.02
0.00
Concentration, ppm

Figure 4-6 United States map of the highest annual arithmetic mean nitrogen dioxide concentration by MSA, 1986.

Table 4-6. Highest Annual Arithmetic Mean Nitrogen Dioxide Concentration by MSA,1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 1

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: > 2 MILLION			
NEW YORK, NY	.041	.042	.049
LOS ANGELES-LONG BEACH, CA	.057	.060	.061
CHICAGO, IL	.044 B	.042	.041
PHILADELPHIA, PA-NJ	.040	.034	.036
DETROIT, MI	.025	.021	IN
WASHINGTON, DC-MD-VA	.032	.036	.035
HOUSTON, TX	.029	.025	.028
BOSTON, MA	.044	.040	.033
NASSAU-SUFFOLK, NY	.035	.033	IN
ST. LOUIS, MO-IL	.033	.033	.035
ATLANTA, GA	.026	.027	.031
MINNEAPOLIS-ST. PAUL, MN-WI	.019	.021	.021
BALTIMORE, MD	.034	.036	.036

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 2

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	.016	.019	.016
PITTSBURGH, PA	.031	.030	.033
ANAHEIM-SANTA ANA, CA	.046	.043	.045
SAN DIEGO, CA	.031	.032	.034
TOTAL MSA'S > 2 MILLION : 17			

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS
CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED.
FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER
24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS
CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA
OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED
SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

PAGE NO: 3

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: 1 - 2 MILLION			
NEWARK, NJ	.042	.043	.032
OAKLAND, CA	.025	.026	.025
CLEVELAND, OH	.029	.030	.027
RIVERSIDE-SAN BERNARDINO, CA	.040	.040	.042
TAMPA-ST. PETERSBURG-CLEARWATER, FL	.021	.019	ND
PHOENIX, AZ	.025	.020	IN
MIAMI-HIALEAH, FL	.009	IN	.019
SEATTLE, WA	.033	.034	IN
DENVER, CO	.047	.047	.047
SAN FRANCISCO, CA	.029	.028	.025
SAN JUAN, PR	ND	ND	ND
KANSAS CITY, MO-KS	.018	.021	.013
CINCINNATI, OH-KY-IN	.030	.029	.029

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.

ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	 1985	 1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	.028	.026	.027
SAN JOSE, CA	.032	.035	.033
NEW ORLEANS, LA	.026	.023 B	.025
BERGEN-PASSAIC, NJ	.037	.034	.030
COLUMBUS, OH	.024	.025	IN
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	.016	.017	.018
SACRAMENTO, CA	.019	.021	.022
INDIANAPOLIS, IN	.024	.021	.020
SAN ANTONIO, TX	.013	.011	ND
FORT WORTH-ARLINGTON, TX	.016	.019	.016
PORTLAND, OR-WA	IN	.018	.019
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	ND	ND	ND
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	.015	.020	.022

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	.037	.038	.035
TOTAL MSA'S 1 - 2 MILLION : 27			

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.

ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION			
ROCHESTER, NY	ND	ND	ND
BUFFALO, NY	.024	.024	.025
OKLAHOMA CITY, OK	.020	.019	.019
LOUISVILLE, KY-IN	.016	IN	.032
MEMPHIS, TN-AR-MS	IN	.016	.024
DAYTON-SPRINGFIELD, OH	.023	.021	IN
MIDDLESEX-SOMERSET-HUNTERDON, NJ	.025	.023	.024
MONMOUTH-OCEAN, NJ	ND	ND	ND
BIRMINGHAM, AL	ND	ND	ND
NASHVILLE, TN	ND	ND	ND
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	.014	.015	.018
ALBANY-SCHENECTADY-TROY, NY	ND	ND	ND
ORLANDO, FL	.010	IN	ND

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	ND	ND	ND
RICHMOND-PETERSBURG, VA	.024	.023	.022
JACKSONVILLE, FL	IN	.015	ND
HARTFORD, CT	.021	.021	.022
SCRANTON-WILKES-BARRE, PA	.020	.022	.019
TULSA, OK	.018	.020	.021
WEST PALM BEACH-BOCA RATON-DELRAY BEACH, FL	.015	.012	ND
SYRACUSE, NY	ND	ND	ND
AKRON, OH	ND	ND	ND
ALLENTOWN-BETHLEHEM, PA-NJ	.024	.019	.021
AUSTIN, TX	ND	ND	ND
GARY-HAMMOND, IN	.010	IN	ND
GRAND RAPIDS, MI	ND	ND	ND

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 8

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	.025	.026	.025
TOLEDO, OH	ND	ND	ND
RALEIGH-DURHAM, NC	ND	ND	ND
OMAHA, NE-IA	ND	ND	ND
TUCSON, AZ	.026	.017	IN
GREENVILLE-SPARTANBURG, SC	ND	ND	ND
KNOXVILLE, TN	ND	ND	ND
OXNARD-VENTURA, CA	.026	.018	.028
HARRISBURG-LEBANON-CARLISLE, PA	.021	.021	.022
FRESNO, CA	.027	.031	.032
JERSEY CITY, NJ	.028	.032	.032
WILMINGTON, DE-NJ-MD	.032	.029	.029
BATON ROUGE, LA	.029 B	.024	.022

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

Table 4-6

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NITROGEN DIOXIDE CONCENTRATION BY MSA POPULATION RANGE — PAGE NO: 9

METROPOLITAN STATISTICAL AREA	NITROGEN DIOXIDE CONCENTRATION (PPM) HIGHEST ANNUAL ARITHMETIC MEAN 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	.029	.021	.022
EL PASO, TX	.021	.024	IN
YOUNGSTOWN-WARREN, OH	.028	ND	ND
TACOMA, WA	ND	ND	ND
SPRINGFIELD, MA	.025	.024	.022
NEW HAVEN-MERIDEN, CT	.031	.031	.029

TOTAL MSA'S .5 - 1 MILLION : 45

NOTE: FOR CONTINUOUS INSTRUMENTS, THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF AT LEAST 4380 HOURLY VALUES ARE COLLECTED. FOR INSTRUMENTS WHICH COLLECT ONLY ONE MEASUREMENT PER 24-HR PERIOD (BUBBLERS), THE ANNUAL ARITHMETIC MEAN IS CALCULATED IF THE DATA SATISFIES THE NADB VALIDITY CRITERIA OR AT LEAST 30 DAYS OF 24-HR DATA (50% OF THE EPA RECOMMENDED SAMPLING DAYS) HAVE BEEN COLLECTED.
ND = NO DATA
IN = INSUFFICIENT DATA TO CALCULATE THE ANNUAL ARITHMETIC MEAN
B = REPRESENTS A 24-HR BUBBLER MEASUREMENT

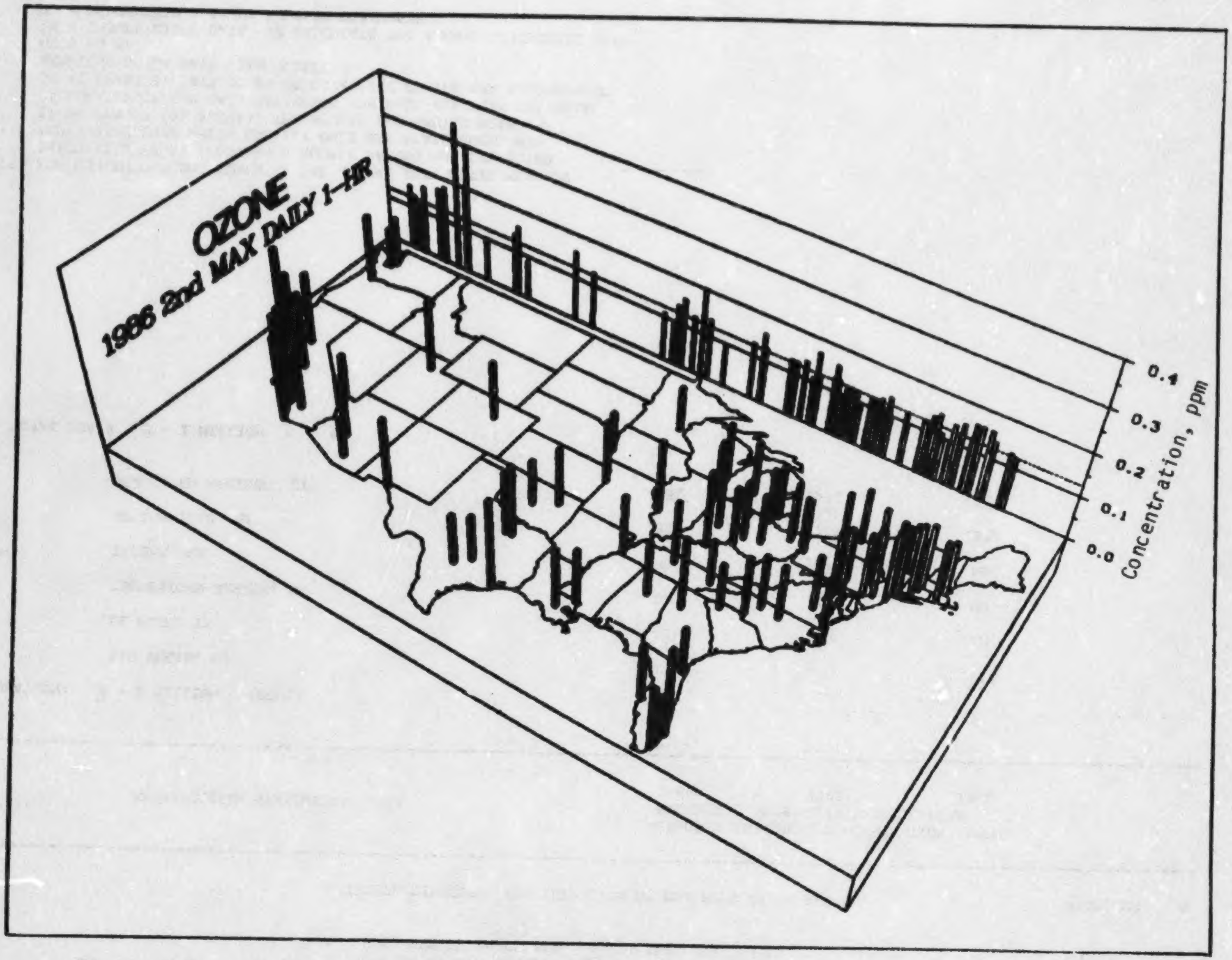
OZONE
1986 2nd MAX DAILY 1-HR
0.4
0.3
0.2
0.1
0.0
Concentration, ppm

Figure 4-7 United States map of the highest second daily maximum 1-hour average ozone concentration by MSA, 1986.

Table 4-7. Highest Second Daily Maximum 1-Hour Average Ozone Concentration by MSA, 1984-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 1

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	CONCENTRATION 1-HR 2ND HIGH 1985	(PPM) DAILY MAX 1986
POPULATION: > 2 MILLION			
NEW YORK, NY	.17	.16	.16
LOS ANGELES-LONG BEACH, CA	.29	.33	.34
CHICAGO, IL	.15	.14	.12
PHILADELPHIA, PA-NJ	.20	.16	.15
DETROIT, MI	.12	.11	.12 *
WASHINGTON, DC-MD-VA	.14	.14 *	.14
HOUSTON, TX	.21	.23	.20
BOSTON, MA	.15	.16	.12
NASSAU-SUFFOLK, NY	.10	.14	.16
ST. LOUIS, MO-IL	.17	.18	.16
ATLANTA, GA	.15	.14	.16
MINNEAPOLIS-ST. PAUL, MN-WI	.12	.10	.10
BALTIMORE, MD	.15	.16	.15 *

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	OZONE CONCENTRATION (PPM) HIGHEST 1-HR 2ND MAX. DAILY MAX 1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	.16	.16 *	.16 *
PITTSBURGH, PA	.11	.12	.12
ANAHEIM-SANTA ANA, CA	.26	.28	.22
SAN DIEGO, CA	.20	.21	.19

TOTAL MSA'S > 2 MILLION : 17

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 3

METROPOLITAN STATISTICAL AREA	OZONE CONCENTRATION (PPM) HIGHEST 1-HR 2ND HIGH DAILY MAX 1984	1985	1986	
POPULATION: 1 - 2 MILLION				
NEWARK, NJ	.12	.14	.13	
OAKLAND, CA	.15	.14	.13	
CLEVELAND, OH	.14	.12	.12	
RIVERSIDE-SAN BERNARDINO, CA	.32	.34	.30	
TAMPA-ST. PETERSBURG-CLEARWATER, FL	.13	.13	.12	
PHOENIX, AZ	.15	.13	.14	*
MIAMI-HIALEAH, FL	.10	.13	.14	
SEATTLE, WA	.09	.11	.11	
DENVER, CO	.12	.11	.13	
SAN FRANCISCO, CA	.11	.11	.08	
SAN JUAN, PR	.08	ND	.08	*
KANSAS CITY, MO-KS	.14	.15	.14	
CINCINNATI, OH-KY-IN	.12	.12	.13	

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 4

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	CONCENTRATION (PPM) 1-HR 1985	2ND HIGH DAILY MAX 1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	.16	.15	.13
SAN JOSE, CA	.16	.15	.12
NEW ORLEANS, LA	.12	.12	.12
BERGEN-PASSAIC, NJ	.16	.14	.12
COLUMBUS, OH	.11	.11	.11
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	.12	.11	.11
SACRAMENTO, CA	.19	.18	.16
INDIANAPOLIS, IN	.12	.12	.11
SAN ANTONIO, TX	.12	.12	.11
FORT WORTH-ARLINGTON, TX	.16	.15	.14
PORTLAND, OR-WA	.13	.13	.15
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	.10	.09	.11
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	.13	.11	.13

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 5

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	1-HR CONCENTRATION 2ND HIGH 1985	(PPM) DAILY MAX 1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	.15	.16	.16
TOTAL MSA'S 1 - 2 MILLION : 27			

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	1-HR CONCENTRATION (PPM) 2ND HIGH DAILY MAX 1985	1986
POPULATION* .5 - 1 MILLION			
ROCHESTER, NY	.11	.11	.12
BUFFALO, NY	.11	.12	.10
OKLAHOMA CITY, OK	.12	.11	.10
LOUISVILLE, KY-IN	.15	.13	.17
MEMPHIS, TN-AR-MS	.13	.13	.13
DAYTON-SPRINGFIELD, OH	.12	.11	.13
MIDDLESEX-SOMERSET-HUNTERDON, NJ	.19	.19	.15
MONMOUTH-OCEAN, NJ	ND	.15	.14
BIRMINGHAM, AL	.11	.12	.12
NASHVILLE, TN	.13	.14	.14
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	.11	.10	.12
ALBANY-SCHENECTADY-TROY, NY	.09	.12	.11
ORLANDO, FL	.11	.11	.12

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	1-HR CONCENTRATION (PPM) 2ND HIGH DAILY MAX 1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	.07	.06	.04
RICHMOND-PETERSBURG, VA	.13	.12	.12
JACKSONVILLE, FL	.11	.14	.10
HARTFORD, CT	.17	.16	.11
SCRANTON-WILKES-BARRE, PA	.11	.11	.10
TULSA, OK	.13	.12	.13
WEST PALM BEACH-BOCA RATON-DELRAY BEACH, FL	.09	.09	.10
SYRACUSE, NY	ND	.08	.10
AKRON, OH	.11	.11	.11
ALLENTOWN-BETHLEHEM, PA-NJ	.13	.12	.12
AUSTIN, TX	.11	.13	.10
GARY-HAMMOND, IN	.15	.12 *	.13
GRAND RAPIDS, MI	.11	.11	.12

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 8

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	1-HR CONCENTRATION (PPM) 2ND HIGH DAILY MAX 1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	.23	.14	.13
TOLEDO, OH	.11	.10	.12
RALEIGH-DURHAM, NC	.10	.11	.12
OMAHA, NE-IA	.10	.10	.09
TUCSON, AZ	.11	.11	.09 *
GREENVILLE-SPARTANBURG, SC	.08 *	.10	.10
KNOXVILLE, TN	.10 *	.10	.10
OXNARD-VENTURA, CA	.17	.18	.18
HARRISBURG-LEBANON-CARLISLE, PA	.12	.11	.11
FRESNO, CA	.15	.16	.17
JERSEY CITY, NJ	.13	.17	.13
WILMINGTON, DE-NJ-MD	.14	.14	.14
BATON ROUGE, LA	.16	.16	.13

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

Table 4-7

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

OZONE   CONCENTRATION BY MSA POPULATION RANGE   PAGE NO: 9

METROPOLITAN STATISTICAL AREA	OZONE HIGHEST 1984	1-HR CONCENTRATION (PPM) 2ND HIGH DAILY MAX 1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	.12	.11	.10
EL PASO, TX	.16 *	.14	.16
YOUNGSTOWN-WARREN, OH	.09	.11	.11
TACOMA, WA	.09	.11	.09 *
SPRINGFIELD, MA	.17	.15	.14
NEW HAVEN-MERIDEN, CT	.20	.15	.16

TOTAL MSA'S .5 - 1 MILLION : 45

* LESS THAN 50% OF DAYS IN OZONE SEASON
ND = NO DATA

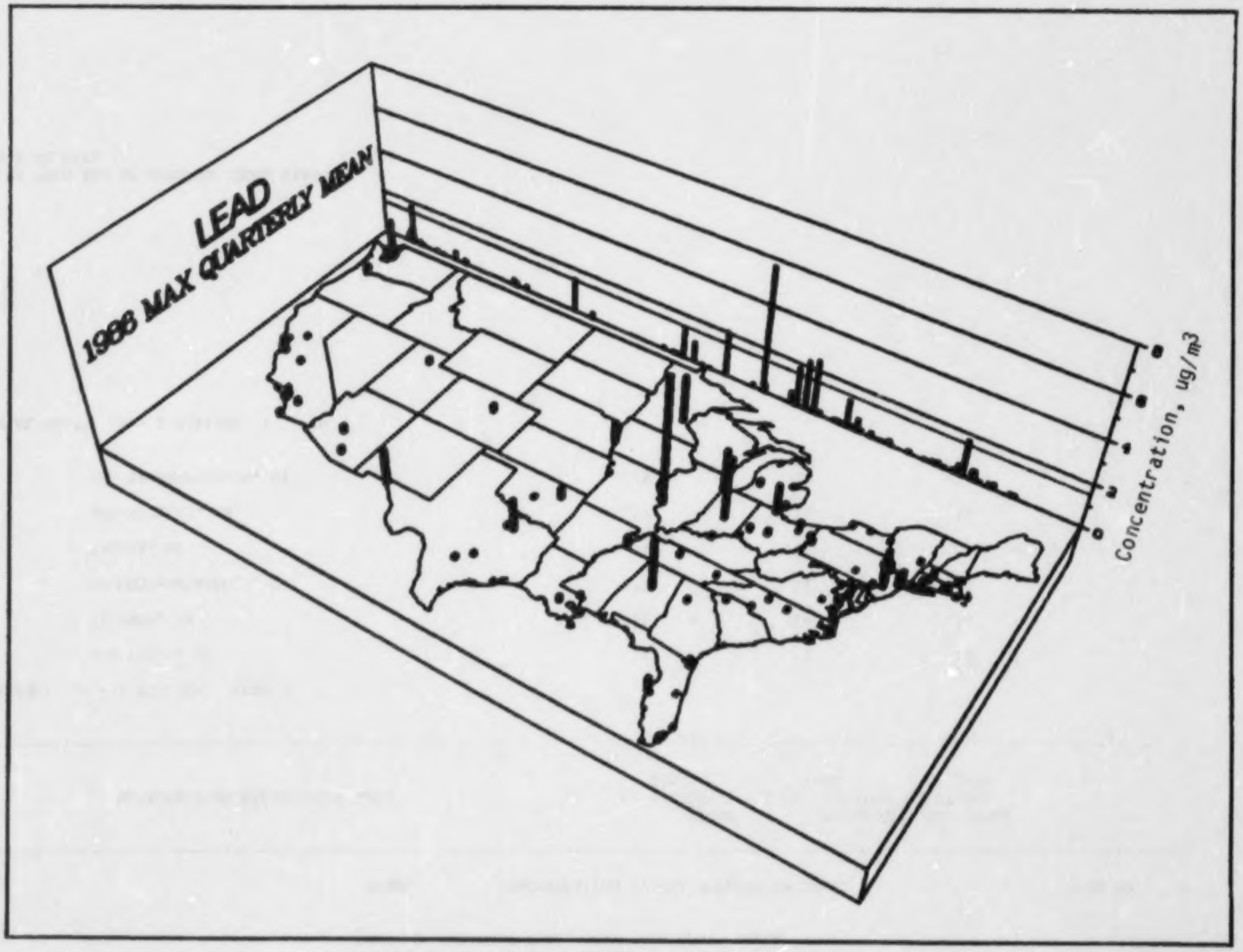
LEAD
1986 MAX QUARTERLY MEAN
0
2
4
6
8
Concentration, ug/m3

Figure 4-8 United States map of the highest maximum quarterly average lead concentration by MSA, 1986.

Table 4-8. Highest Maximum Quarterly Average Lead Concentration by MSA, 1985-1986.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD   CONCENTRATION BY MSA POPULATION RANGE   PAGE NO: 1

METROPOLITAN STATISTICAL AREA	LEAD HIGHEST 1984	CONCENTRATION (UG/M3) MAXIMUM QUARTERLY AVERAGE 1985	 1986
POPULATION: > 2 MILLION			
NEW YORK, NY	.91	.60	.53
LOS ANGELES-LONG BEACH, CA	1.03	.63	.44
CHICAGO, IL	.68	1.05	.48
PHILADELPHIA, PA-NJ	5.13	2.07	1.72 *
DETROIT, MI	.69 Q	.27 M	.20 M
WASHINGTON, DC-MD-VA	.49	.21	.37
HOUSTON, TX	.39	.26	.12
BOSTON, MA	.48	.43	.19
NASSAU-SUFFOLK, NY	.67	.45	.14
ST. LOUIS, MO-IL	2.41	4.61	5.70 *
ATLANTA, GA	.47 M	.19 M	.15 M
MINNEAPOLIS-ST. PAUL, MN-WI	1.01	.89	2.09 *
BALTIMORE, MD	.60	.37	.23

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF INDUSTRIAL PB SOURCES.
1986 PB LEVELS FOR THE HIGHEST POPULATION ORIENTED SITES ARE AS FOLLOWS:
PHILADELPHIA (0.14 UG/M3), ST. LOUIS (0.35 UG/M3) AND MINNEAPOLIS (0.14 UG/M3).
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 2

METROPOLITAN STATISTICAL AREA	LEAD CONCENTRATION (UG/M3) HIGHEST MAXIMUM QUARTERLY AVERAGE 1984	1985	1986
POPULATION: > 2 MILLION (CONT)			
DALLAS, TX	1.52	2.01	1.42 *
PITTSBURGH, PA	.33	.24	.18
ANAHEIM-SANTA ANA, CA	.61	.34	.22
SAN DIEGO, CA	.53	.29	.23
TOTAL MSA'S > 2 MILLION : 17			

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF A PB RECLAMATION PLANT OUTSIDE DALLAS.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN DALLAS IS 0.09 UG/M3.
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 3

METROPOLITAN STATISTICAL AREA	LEAD CONCENTRATION (UG/M3) HIGHEST MAXIMUM QUARTERLY AVERAGE 1984	1985	1986
POPULATION: 1 - 2 MILLION			
NEWARK, NJ	.56	.51	.46
OAKLAND, CA	.29	.16	.16
CLEVELAND, OH	.38 M	.34 M	.20 M
RIVERSIDE-SAN BERNARDINO, CA	.55	.31	.21
TAMPA-ST. PETERSBURG-CLEARWATER, FL	.57	.31	.61
PHOENIX, AZ	1.29	.72	.31
MIAMI-HIALEAH, FL	.93	.58	.26
SEATTLE, WA	1.56 M	1.55 M	1.82 *
DENVER, CO	.90 M	.70 M	.30 M
SAN FRANCISCO, CA	.43	.26	.20
SAN JUAN, PR	1.30	1.26	.30
KANSAS CITY, MO-KS	.34	.41	.08
CINCINNATI, OH-KY-IN	.50 M	.25 M	.12

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF INDUSTRIAL PB SOURCES.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN SEATTLE IS 0.26 UG/M3.
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

METROPOLITAN STATISTICAL AREA	LEAD CONCENTRATION (UG/M3) HIGHEST MAXIMUM QUARTERLY AVERAGE 1984	1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
MILWAUKEE, WI	.72	.61	.57
SAN JOSE, CA	.51	.42	.22
NEW ORLEANS, LA	.56	.22	.13
BERGEN-PASSAIC, NJ	.92	.62	.22
COLUMBUS, OH	.62 M	.52 M	.20 M
NORFOLK-VIRGINIA BEACH-NEWPORT NEWS, VA	.33	.14	.09
SACRAMENTO, CA	.47	.30	.12
INDIANAPOLIS, IN	1.14	1.64	2.49 *
SAN ANTONIO, TX	.67	.35	.14
FORT WORTH-ARLINGTON, TX	.57	.40	.14
PORTLAND, OR-WA	1.58	1.00 M	.36 M
FORT LAUDERDALE-HOLLYWOOD-POMPANO BEACH, FL	.23	.18	.09
CHARLOTTE-GASTONIA-ROCK HILL, NC-SC	.44	.22	.10

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF A PB BATTERY PLANT.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN INDIANAPOLIS IS 0.14 UG/M3.
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 5

METROPOLITAN STATISTICAL AREA	LEAD HIGHEST 1984	CONCENTRATION (UG/M3) MAXIMUM QUARTERLY AVERAGE 1985	1986
POPULATION: 1 - 2 MILLION (CONT)			
SALT LAKE CITY-OGDEN, UT	.66	.63	.22
TOTAL MSA'S 1 - 2 MILLION : 27			

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 6

METROPOLITAN STATISTICAL AREA	LEAD HIGHEST 1984	CONCENTRATION (UG/M3) MAXIMUM QUARTERLY AVERAGE 1985	1986
POPULATION: .5 - 1 MILLION			
ROCHESTER, NY	.67	.55	.10
BUFFALO, NY	.51	.32	.16
OKLAHOMA CITY, OK	.59	.37	.11
LOUISVILLE, KY-IN	.60 M	.45 M	.18 M
MEMPHIS, TN-AR-MS	1.41	.88	.44
DAYTON-SPRINGFIELD, OH	.52 M	.45 M	.19 M
MIDDLESEX-SOMERSET-HUNTERDON, NJ	1.73	.81	.36
MONMOUTH-OCEAN, NJ	ND	ND	ND
BIRMINGHAM, AL	5.33	1.59	2.30 *
NASHVILLE, TN	.36	.54	.17
GREENSBORO-WINSTON SALEM-HIGH POINT, NC	.50	.18	.10
ALBANY-SCHENECTADY-TROY, NY	.48	.22	.13
ORLANDO, FL	.40	.18	.07

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF INDUSTRIAL PB SOURCES.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN BIRMINGHAM IS 0.30 UG/M3.
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 7

METROPOLITAN STATISTICAL AREA	LEAD CONCENTRATION (UG/M3) HIGHEST MAXIMUM QUARTERLY AVERAGE 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
HONOLULU, HI	1.00	.26	.19
RICHMOND-PETERSBURG, VA	.46	.16	.08
JACKSONVILLE, FL	1.26	.66	.27
HARTFORD, CT	.57	.57 M	.17 M
SCRANTON-WILKES-BARRE, PA	.46	.22	.14
TULSA, OK	.75	.83	.47
WEST PALM BEACH-BOCA RATON-DELRAY BEACH, FL	.33	.18	.07
SYRACUSE, NY	.46	.27	.13
AKRON, OH	.46 M	.32 M	.07
ALLENTOWN-BETHLEHEM, PA-NJ	1.13	1.52	.48
AUSTIN, TX	ND	.18	.13
GARY-HAMMOND, IN	2.95	12.50	1.81 *
GRAND RAPIDS, MI	.66	.35	.21

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF A LEAD BATTERY PLANT IN HAMMOND, IN.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN GARY-HAMMOND IS 0.16 UG/M3.
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE

METROPOLITAN STATISTICAL AREA	LEAD CONCENTRATION (UG/M3) HIGHEST MAXIMUM QUARTERLY AVERAGE 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
PROVIDENCE, RI	.58	.53	.18
TOLEDO, OH	.19	.11	1.29 M*
RALEIGH-DURHAM, NC	.54	.18	.10
OMAHA, NE-IA	.91	.75	.97
TUCSON, AZ	.59	.58	.24
GREENVILLE-SPARTANBURG, SC	.65	.31	.17
KNOXVILLE, TN	.43	.18	.13
OXNARD-VENTURA, CA	.29	.17	.08
HARRISBURG-LEBANON-CARLISLE, PA	.34	.13	.09
FRESNO, CA	.60	.37	.15
JERSEY CITY, NJ	.94	.37	.15
WILMINGTON, DE-NJ-MD	.63	.30	.20
BATON ROUGE, LA	.58	.50	.21

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF AN INDUSTRIAL SOURCE IN DELTA, OH.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN TOLEDO IS 0.06 UG/M3.
ND = NO DATA

Table 4-8

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING AND STANDARDS
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

LEAD CONCENTRATION BY MSA POPULATION RANGE PAGE NO: 9

METROPOLITAN STATISTICAL AREA	LEAD CONCENTRATION (UG/M3) HIGHEST MAXIMUM QUARTERLY AVERAGE 1984	1985	1986
POPULATION: .5 - 1 MILLION (CONT)			
LAS VEGAS, NV	.55	.27	ND
EL PASO, TX	1.60	4.31	1.57 *
YOUNGSTOWN-WARREN, OH	.31	.15	.11
TACOMA, WA	.47	.97	.59
SPRINGFIELD, MA	1.09	.72	.29
NEW HAVEN-MERIDEN, CT	.55 M	.45 M	.24 M

TOTAL MSA'S .5 - 1 MILLION : 45

M = REPRESENTS MONTHLY COMPOSITE DATA
Q = REPRESENTS QUARTERLY COMPOSITE DATA
* = THIS LEVEL REFLECTS THE IMPACT OF A LEAD SMELTER.
1986 PB LEVEL FROM THE HIGHEST POPULATION ORIENTED SITE IN EL PASO IS 0.58 UG/M3.
ND = NO DATA

5. TRENDS ANALYSES FOR 14 URBANIZED AREAS

This chapter presents trends in ambient air quality for the period 1982 - 1986 in 14 urbanized areas. The urbanized areas included in these analyses are Atlanta, GA; Baltimore, MD; Boston, MA; Chicago, IL-Northwestern IN; Denver, CO; Detroit, MI; Houston, TX; Los Angeles-Long Beach, CA; New York, NY-Northeastern NJ; Philadelphia, PA-NJ; Phoenix, AZ; Portland, OR-WA; Seattle, WA; and St. Louis, MO-IL. These areas have been selected because they were among the largest cities in each of the EPA Regions.

Where sufficient data were available, trends in these areas are presented for the criteria pollutants TSP, SO_2, CO, NO_2, O_3, and Pb. Also, the urbanized areas are grouped into five broad geographic areas: East, Midwest, South, Southwest, and Northwest, and composite averages calculated for each pollutant are presented and are compared to the national averages.

The air quality data used for the trend statistics in this chapter have been obtained from the EPA National Aerometric Data Bank (NADB) with additional limited data taken from State annual reports. The monitoring sites used for the trends analyses had to satisfy the historical continuity criterion of 4 out of 5 years of data for the period 1982 to 1986, except for lead, which required 1 valid quarter per year. Furthermore, data for each year generally had to meet the annual data completeness criteria as described in Section 2.1.

The urbanized area air quality trends focus on the period 1982 through 1986, complementing the 5-year national trends analyses in Section 3. The national trends analyses also produce a 10-year trend (1977 to 1986). Several of the urbanized areas did not have sufficient data to meet the 8 of 10-year data completeness criterion, so only the 5-year trend is presented for these.

The air quality trends in this chapter (except for O_3) are based on information from monitoring sites within the urbanized areas as defined in the 1980 Census of Population Report prepared by the U.S. Bureau of Census.[1] This report defines an urbanized area as a central city or cities and surrounding closely settled territory (urban fringe). For O_3, since maximum concentrations generally occur downwind of an urbanized area, downwind sites located outside of the urbanized area boundaries were used in the trends analyses.

Figure 5-1 shows the plotting convention used in trends analyses. For 1982-1986, the maximum and minimum values are shown as well as the composite average of the sites used. The maximum and minimum values are measured concentrations, and values for missing years were interpolated to calculate the appropriate averages. Table 5-1 shows the air quality statistics used in the trends analyses for the 14 cities.

The air quality data and trends presented in this chapter should not be used to make direct city to city comparisons, since the mix, configuration, and number of sites composing the area networks are different. Furthermore, other parameters, such as population density, transportation patterns, industrial composition, emission sources, and meteorological characteristics, also need to be taken into consideration.

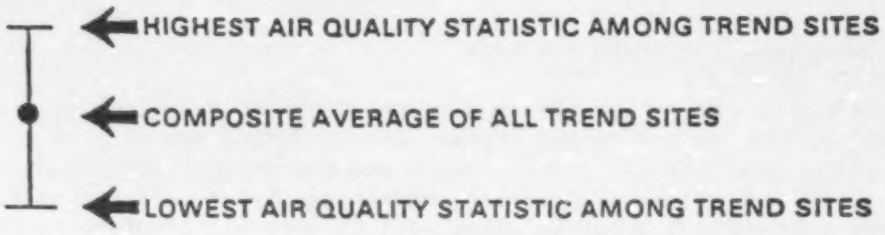
HIGHEST AIR QUALITY STATISTIC AMONG TREND SITES
COMPOSITE AVERAGE OF ALL TREND SITES
LOWEST AIR QUALITY STATISTIC AMONG TREND SITES

FIGURE 5-1. ILLUSTRATION OF PLOTTING CONVENTIONS FOR RANGES USED IN URBANIZED AREA TREND ANALYSIS.

TABLE 5-1. AIR QUALITY TREND STATISTICS AND THEIR ASSOCIATED NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)*

POLLUTANT	TREND STATISTICS	PRIMARY NAAQS CONCENTRATION
Total Suspended Particulate**	annual geometric mean	75 ug/m^3
Sulfur Dioxide	annual arithmetic mean	0.03 ppm (80 ug/m^3)
Carbon Monoxide	second highest nonoverlapping 8-hour average	9 ppm (10 mg/m^3)
Nitrogen Dioxide	annual arithmetic mean	0.053 ppm (100 ug/m^3)
Ozone	second highest daily maximum 1-hour average	0.12 ppm (235 ug/m^3)
Lead	maximum quarterly average	1.5 ug/m^3

ug/m^3 = micrograms per cubic meter

ppm = parts per million

mg/m^3 = milligrams per cubic meter

*See Table 2-1 for a more detailed description of NAAQS
**Replaced by PM$_{10}$ on July 1, 1987 (see Section 3.1)

5.1 BOSTON, MASSACHUSETTS URBANIZED AREA

Boston is the largest urbanized area in the State of Massachusetts and the eighth largest in the United States, with a 1980 population of 2,678,762. It includes all of Suffolk County and the greater portion of Norfolk County, plus portions of Plymouth, Middlesex, Essex, and Worcester Counties. The area extends about 51 miles east to west and about 46 miles north to south, at the greatest distances.

The Boston basin, a territory within a range of hills, has rolling topographical physical features, and is split by the Charles and Mystic Rivers. Because of the confinement, many tall buildings and light industrial, commercial, and residential land use complexes are in proximity. Numerous small factories and a great diversification of industries are found in this area, including electrical, food, printing and publishing, transportation equipment, fabricated metal, and rubber products. Boston is the chief United States Atlantic Ocean fishing port. A large network of railroads and truck lines serves this port.

The meteorology of the area is complex. Prevailing winds are from the northwest in the winter and southwest in the summer. During the summer, the land sea-breeze effect allows pollutants to be transported out over the sea and then returned to the inland area. The trends graphs are displayed in Figure 5-2.

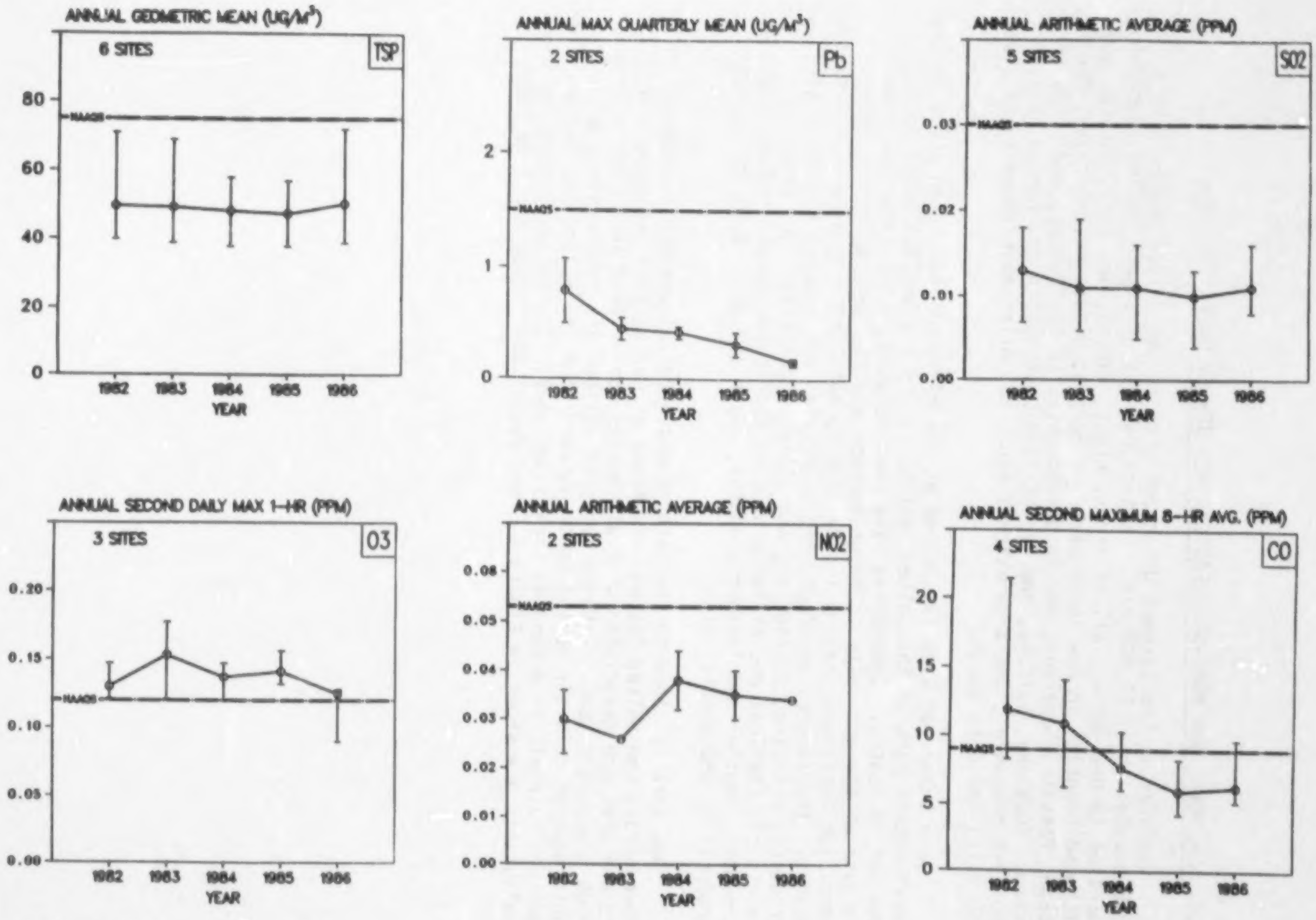

Figure 5-2. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Boston, MA Urbanized Area, 1982-1986.

5.2 NEW YORK, NEW YORK-NORTHEASTERN NEW JERSEY URBANIZED AREA

New York is the largest urbanized area in the United States with a 1980 population of 15,590,274. It includes all of Essex, Hudson, and Union Counties in New Jersey; all of Bronx, Kings, Nassau, New York, Queens, and Richmond Counties in New York; parts of Bergen, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, and Sussex Counties in New Jersey; and parts of Putnam, Rockland, Suffolk, and Westchester Counties in New York. At its greatest distances, the area extends about 105 miles east to west and about 110 miles north to south.

This urbanized area is located at the mouth of the Hudson River in the northeastern part of the United States. It is the busiest ocean port in the United States. Industries have concentrated in the urbanized area because of the proximity to major markets and the easy access to transportation facilites, making it the leading manufacturing area in the United States. Its largest manufacturing industries are apparel and other finished products; printing, publishing, and allied industries; food products; machinery; chemical and allied products; fabricated metal products; textile products; leather and leather products; paper products; auto and aircraft production; and shipbuilding.

New York is close to the path of most frontal weather systems which move across the United States. Extremes of hot weather, which may last up to one week are associated with air masses moving over land from a Bermuda high pressure system. Extremes in cold weather are from rapidly moving outbreaks of cold air moving southeastward from the Hudson Bay region. The average rainfall is around 41 inches per year. The trends graphs for the pollutants are shown in Figure 5-3 and depict the trends for 1982-1986.

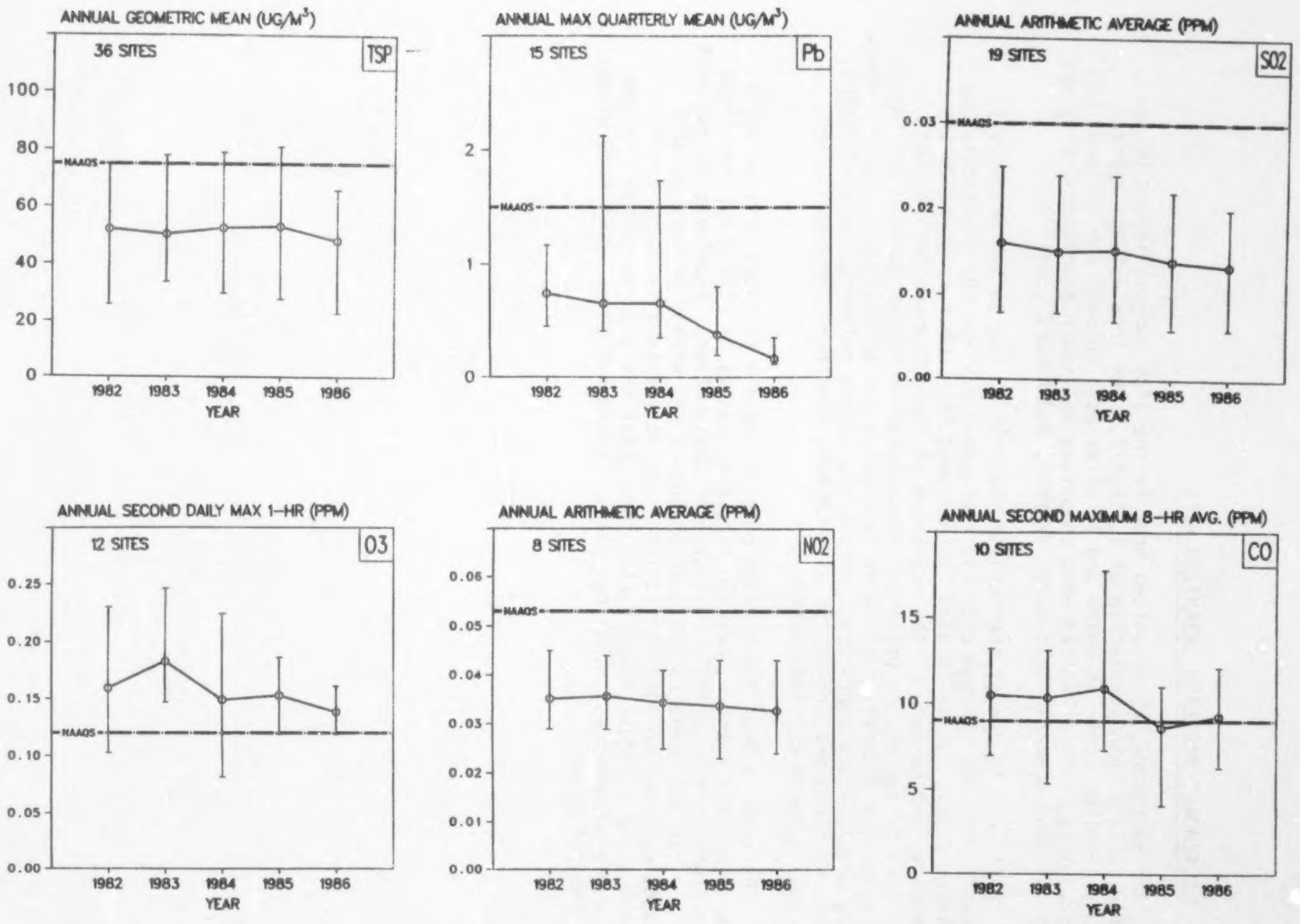

Figure 5-3. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the New York, NY-NJ Urbanized Area, 1982-1986.

5.3 BALTIMORE, MARYLAND URBANIZED AREA

The Baltimore, MD urbanized area is the 14th largest in the United States, with a 1980 population of 1,755,477. The area extends approximately 40 miles north to south and 32 miles east to west and includes 523 square miles. The urbanized area comprises Baltimore independent city and parts of Anne Arundel, Baltimore, Harford, and Howard counties.

Baltimore is one of the busiest seaports in the United States with access to the sea through both the Chesapeake Bay and the Chesapeake and Delaware Canal. It is located farther west than other seaports in the Northeast, and because of the economics of lower transportation costs, Baltimore is one of the principal transportation routes between the East Coast and the Midwest. Its major industries are shipbuilding, steel production, chemical and fertilizer production, copper refining, sugar refining, transportation, and production of aluminum, electronic equipment, and numerous other small industries.

The area is near the average path of the low pressure systems which move across the country, causing frequent changes in wind direction which contribute to the variable character of the weather. Mountains to the west and the bay and ocean to the east produce a net effect of more equable climate compared to continental locations at the same latitude farther inland. The rainfall distribution throughout the year is rather uniform and averages about 43 inches per year. Figure 5-4 shows the trends graphs for the pollutants.

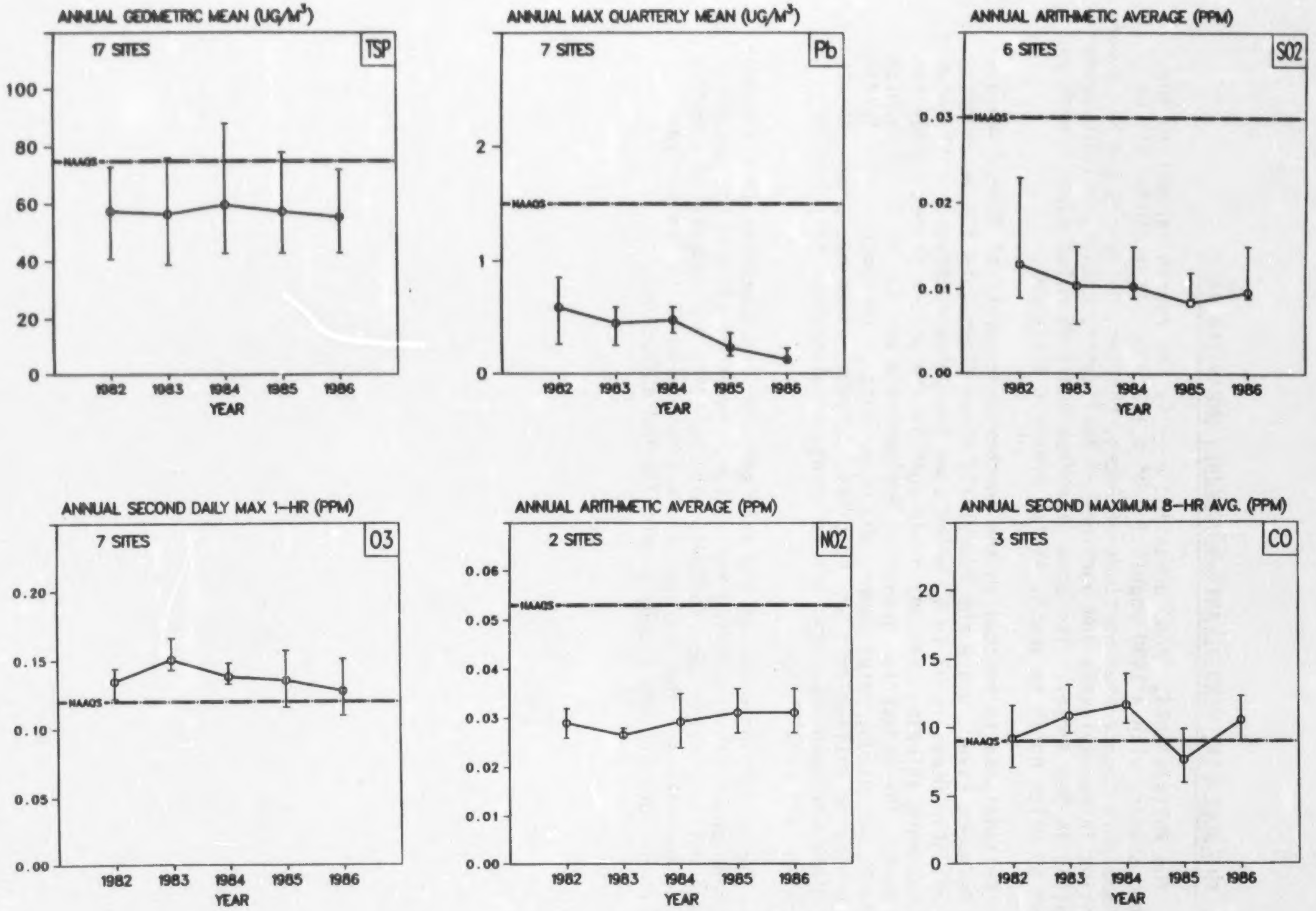

Figure 5-4. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Baltimore, MD Urbanized Area, 1982-1986.

5.4 PHILADELPHIA, PENNSYLVANIA-NEW JERSEY URBANIZED AREA

The Philadelphia, PA-NJ urbanized area is the fourth largest in the United States, with a 1980 population of 4,112,933. It includes all of Philadelphia County plus portions of Bucks, Chester, Delaware, and Montgomery Counties in Pennsylvania and portions of Burlington, Camden, and Gloucester Counties in New Jersey. The area stretches about 65 miles east to west and about 50 miles north to south, at its greatest distances.

Philadelphia is located in the southeastern corner of Pennsylvania on the Delaware River, where the Schuylkill River flows into the Delaware. The Atlantic Ocean is 85 to 90 miles down the Delaware River. Philadelphia handles more shipping than any other port in the United States except for New York. The industrial growth of Philadelphia was due to its proximity to coal, petroleum, water power, and other natural resources. The leading industries in Philadelphia are textiles, carpets, clothing, paper, chemicals, and glassware manufacturing, oil refining, metalworking, ship building, printing, and publishing.

The prevailing winds of the area are from the southwest in the summer and from the northwest during the winter. Maritime air and the proximity to the Delaware River contribute to high humidity and temperatures during the summer months. The average rainfall is around 42 inches per year. Figure 5-5 depicts the trends graphs for the pollutants.

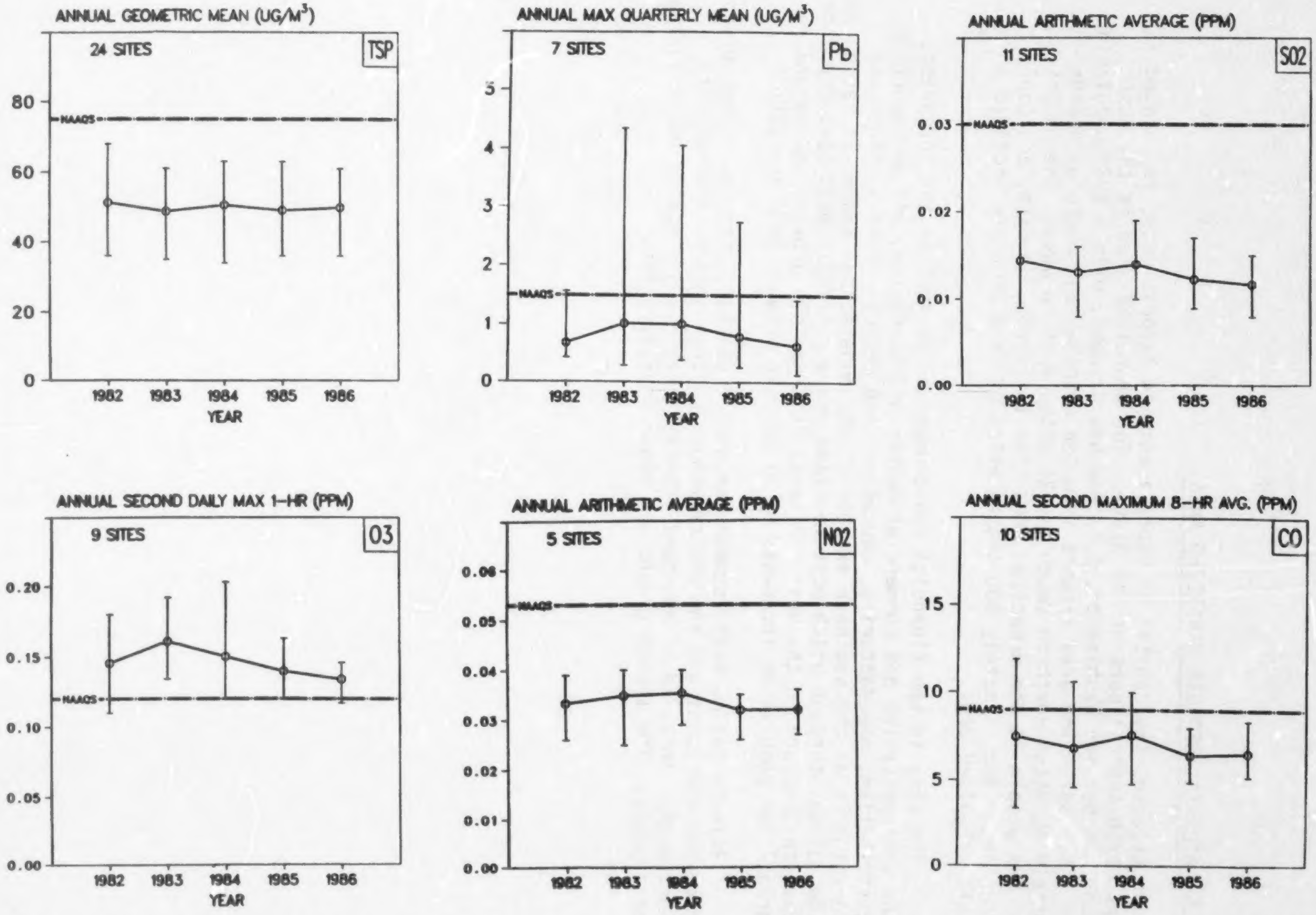

Figure 5-5. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Philadelphia, PA-NJ Urbanized Area, 1982-1986.

5.5 ATLANTA, GEORGIA URBANIZED AREA

Atlanta, the capital of Georgia and its largest city, is located in the north-central part of the State. The urbanized area is the most populous between Washington, D.C. and New Orleans, with a 1980 population of 1,613,357. The area extends into ten counties and measures approximately 40 miles north to south and 35 miles east to west. The majority of the people in the urbanized area live in Fulton, De Kalb, and Cobb Counties. Approximately 500 square miles of land area are included in this urbanized area.

The city is the financial and commercial capital of the Southeast, the transportation and commercial center of the region, and an important distribution, manufacturing, education, and medical center. Since its location is at the southern extreme of the Appalachian Range, it has become the gateway through which most overland and air traffic must pass from the Eastern Seaboard to the West. Atlanta is a rapidly growing and expanding area. The population increased by 37 percent between 1970 and 1980.

Atlanta has moderate summer and winter weather, with the summer winds from the northwest and the winter winds fluctuating from southwest to northwest. In spite of abundant rainfall, serious dry spells occur during most years. The trends graphs are shown in Figure 5-6.

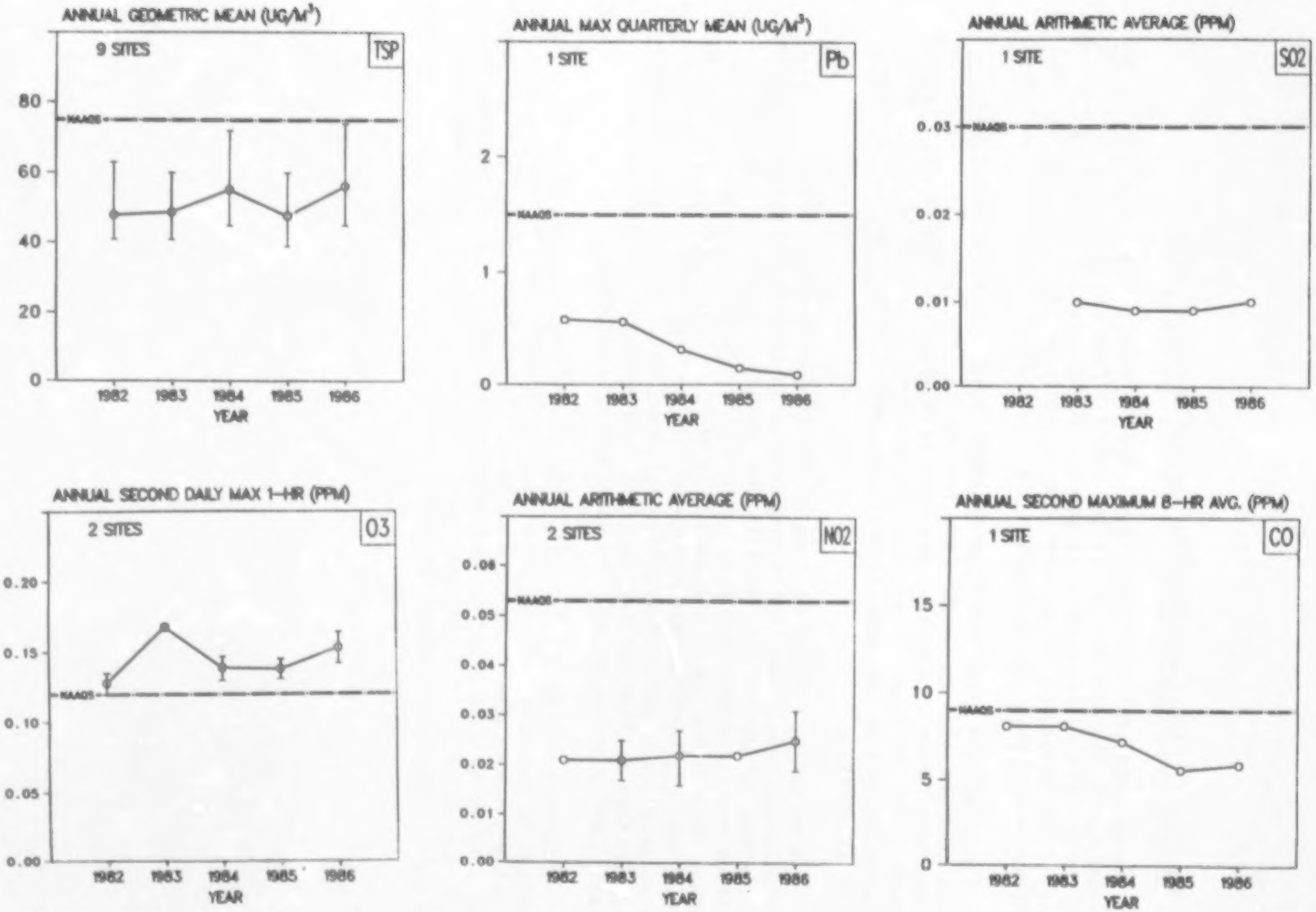

Figure 5-6. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Atlanta, GA Urbanized Area, 1982-1986.

5.6 CHICAGO, ILLINOIS-NORTHWESTERN INDIANA URBANIZED AREA

The Chicago urbanized area covers approximately 1300 square miles and includes 6,770,000 people. It is the third largest area in the nation in population, with approximately 75 percent of the population living in Cook County. The remaining 25 percent live in parts of Lake, Du Page and Will Counties in Illinois and portions of Lake and Porter Counties in Indiana.

The urbanized area runs from Waukegan (near the Wisconsin border) around Lake Michigan to Chesterton, Indiana to the east. The southern and western boundaries of the area are very irregular. To the south, the area extends as far as Crown Point, Indiana and Park Forest South in Illinois. The area extends as far west as Bartlett, West Chicago, and Napierville, all in Illinois.

Economically, Chicago is a major center for transportation, manufacturing, and commercial enterprises. In transportation, Chicago has the largest air and rail traffic in the country. Because of Chicago's location and large manufacturing concerns, it has developed an extensive highway network for local and through traffic. Additionally, the Port of Chicago on Lake Michigan has developed into an important inland port for raw materials and point of transfer for the Great Lakes-Atlantic trade. Among Chicago's chief manufactures are food products, primary metals (steel), and both electrical and nonelectrical machinery.

Chicago occupies a relatively flat plains area bounded by Lake Michigan to the east. The climate is predominately continental, with relatively warm summers and cold winters. Temperature extremes are somewhat altered by Lake Michigan and other Great Lakes. Annual precipitation is on the order of 33 inches per year. Figure 5-7 shows the trends for all the pollutants in the urbanized area.

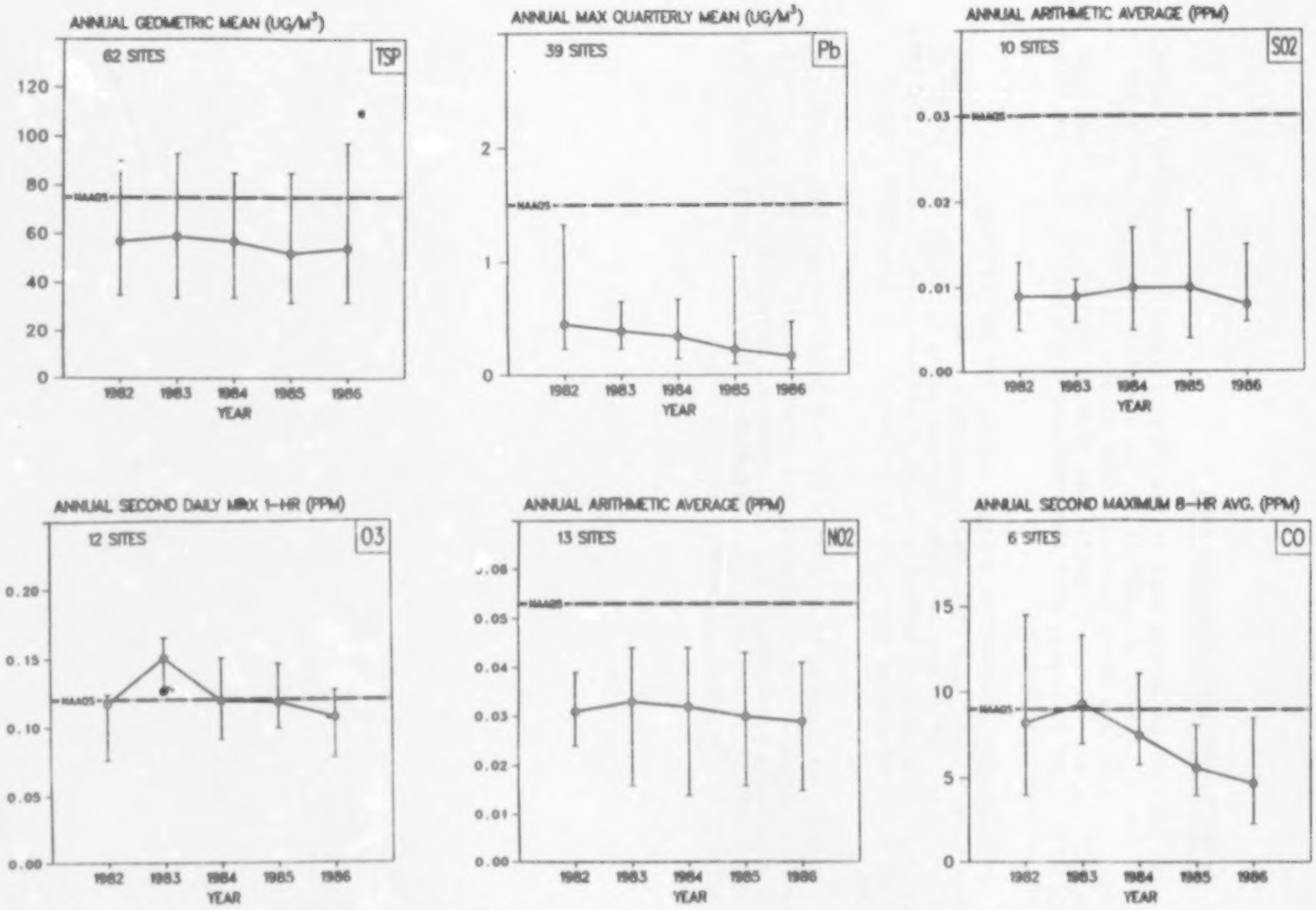

Figure 5-7. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Chicago, IL-IN Urbanized Area, 1982-1986.

5.7 DETROIT, MICHIGAN URBANIZED AREA

The Detroit urbanized area is the fifth largest in the United States, with a 1980 population of 3,809,327. The urbanized area includes Macomb, Monroe, Oakland, and Wayne Counties, with a total land area of approximately 870 square miles. Slightly less than 60 percent of the urban area population lives in Wayne, with the remainder about equally divided between Macomb and Oakland Counties.

Economically, Detroit is a major center for the manufacturing of automobiles, trucks, and other heavy equipment. As such it has developed iron and steel facilities and other manufacturing to support the principal industries. Because of Detroit's location between Lake Huron and Lake Erie and of its manufactured goods, it has become a major seaport in foreign trade.

Detroit is located in a relatively flat plain between Lake Huron and Lake Erie, which serves to moderate the predominately continental climate with relatively warm summers and cold winters. Annual precipitation is approximately 31 inches per year. Figure 5-8 shows the trends for all the pollutants in the urbanized area.

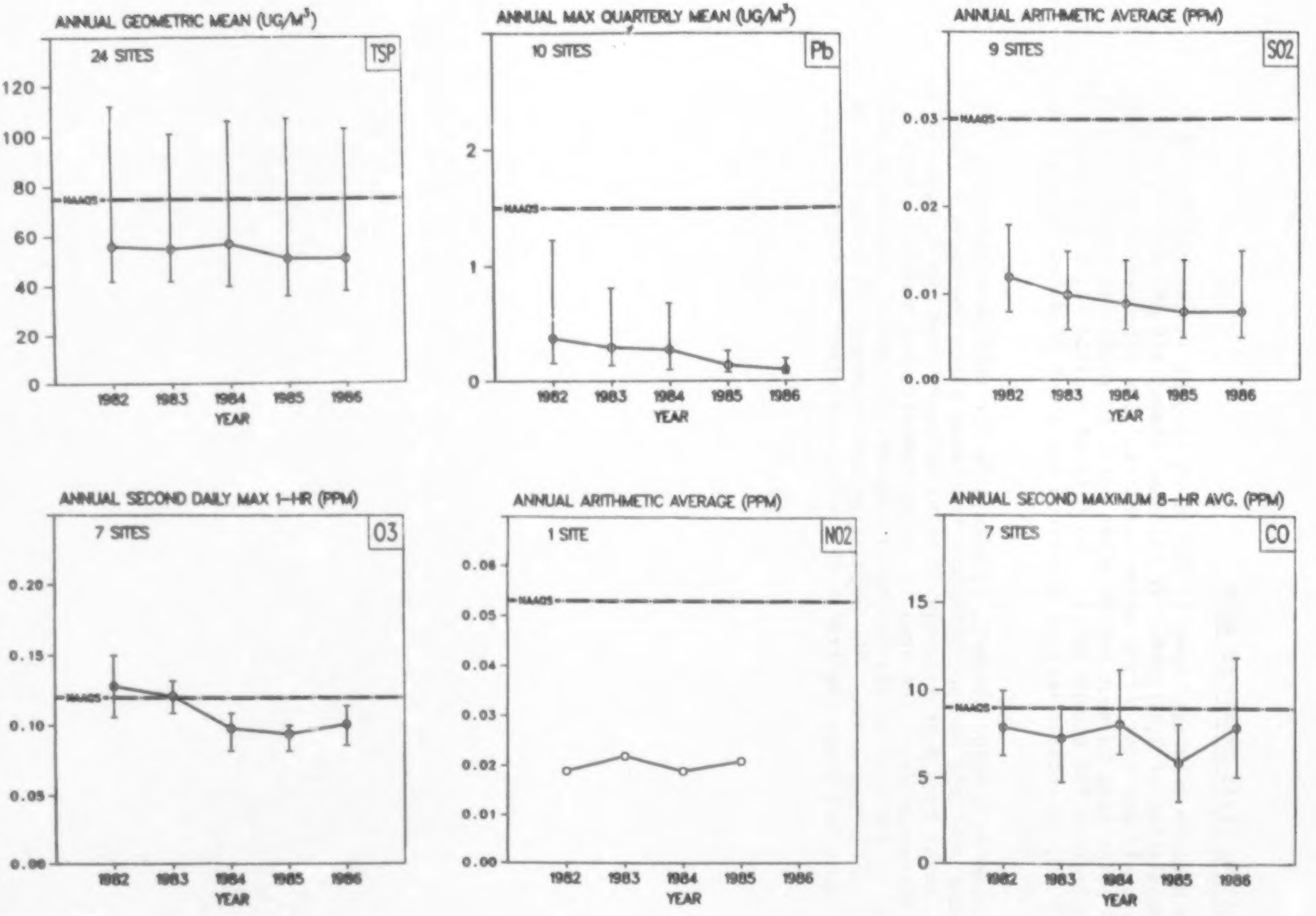

Figure 5-8. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Detroit, MI Urbanized Area, 1982-1986.

5.8 HOUSTON, TEXAS URBANIZED AREA

The Houston urbanized area is the tenth largest in the United States with a population of 2,412,664. It includes almost all of Harris County and very small portions of six other counties. The urbanized area extends about 55 miles east to west and 45 miles north to south and covers a total of approximately 750 square miles. The City of Houston has a population of 1,595,138 and is located west of Galveston Bay about 50 miles inland from the Gulf of Mexico.

Houston is a major seaport, particularly for petroleum products, and it has many refinery and petrochemical complexes along the Houston Ship Channel, which runs approximately 20 miles eastward from the Houston center city to Galveston Bay. The area is in the Sunbelt, has a mild climate moderated by the Gulf of Mexico, and is one of the fastest growing of all the major urbanized areas. The population has increased 44 percent since 1970. Figure 5-9 shows the trends of the six pollutants during the study period.

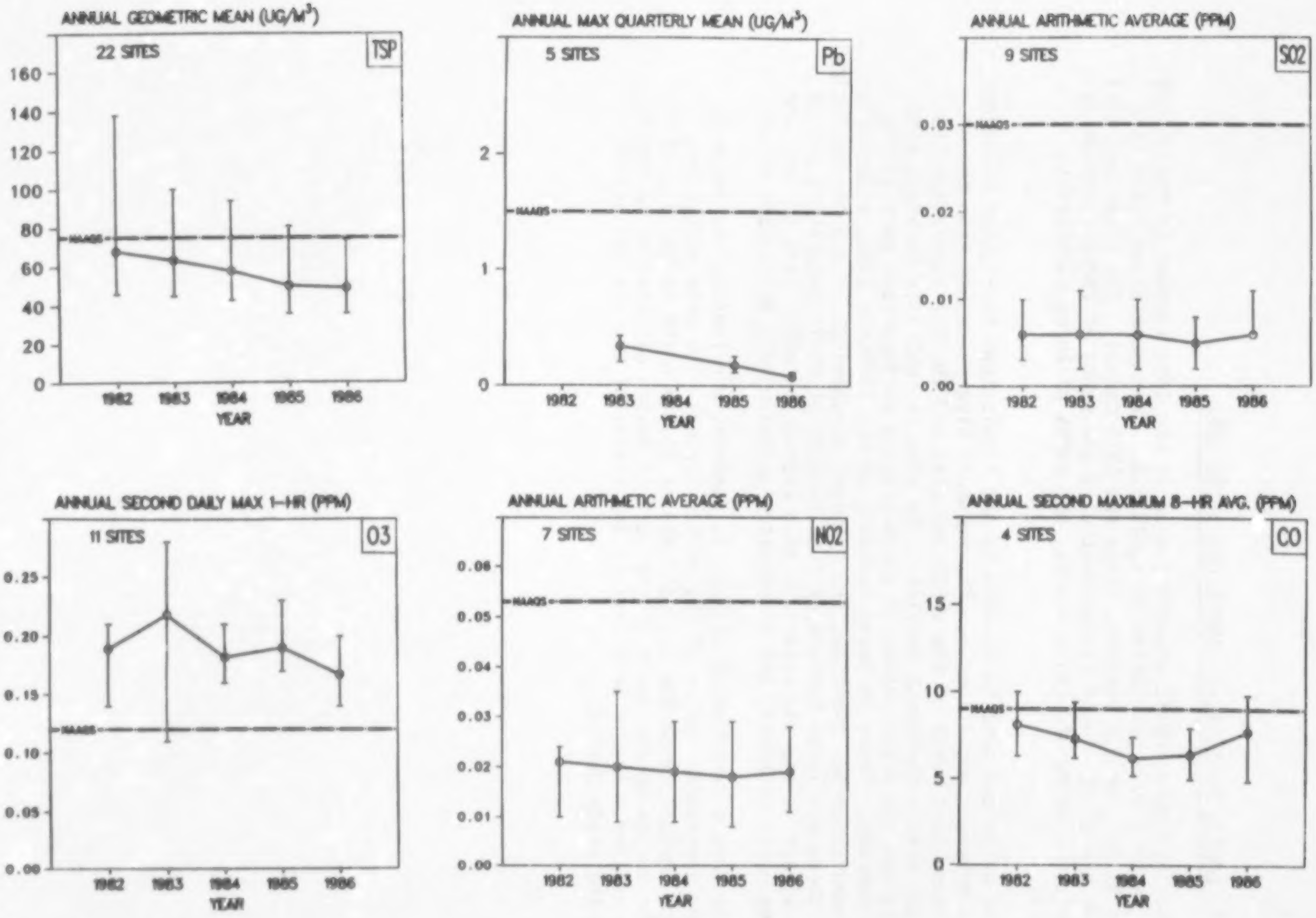

Figure 5-9. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Houston, TX Urbanized Area, 1982-1986.

5.9 ST. LOUIS, MISSOURI-ILLINOIS URBANIZED AREA

The St. Louis, MO-IL urbanized area is the 11th largest in the United States, with a 1980 population of 1,848,590. This population reflects a loss of 33,354, or 1.8 percent, since the 1970 census. The urbanized area includes all of St. Louis independent city and parts of three counties in Missouri, including St. Louis County, and parts of three counties in Illinois.

The urbanized area is divided by the Mississippi River, the boundary between Missouri and Illinois. The Missouri River branches from the Mississippi just north of the urbanized area and further subdivides the urbanized area's northwest section. The area is centrally located, with commerce and the distribution of goods playing an important part in the area's economy. There is heavy industry on the Illinois side, especially steel manufacturing, smelting, and chemical processing. Along the Misissippi River, there are large numbers of fuel burning electric generating plants. At its widest point, the urbanized area extends 48 miles east to west and 32 miles north to south, and encompasses approximately 509 square miles.

The area's continental climate is somewhat modified by its location near the geographic center of the United States. The area enjoys four distinct seasons, with the cold air masses to the north in Canada and the warm air masses to the south in the Gulf of Mexico alternating in control of the weather. Figure 5-10 depicts the trends of the six pollutants during the study period.

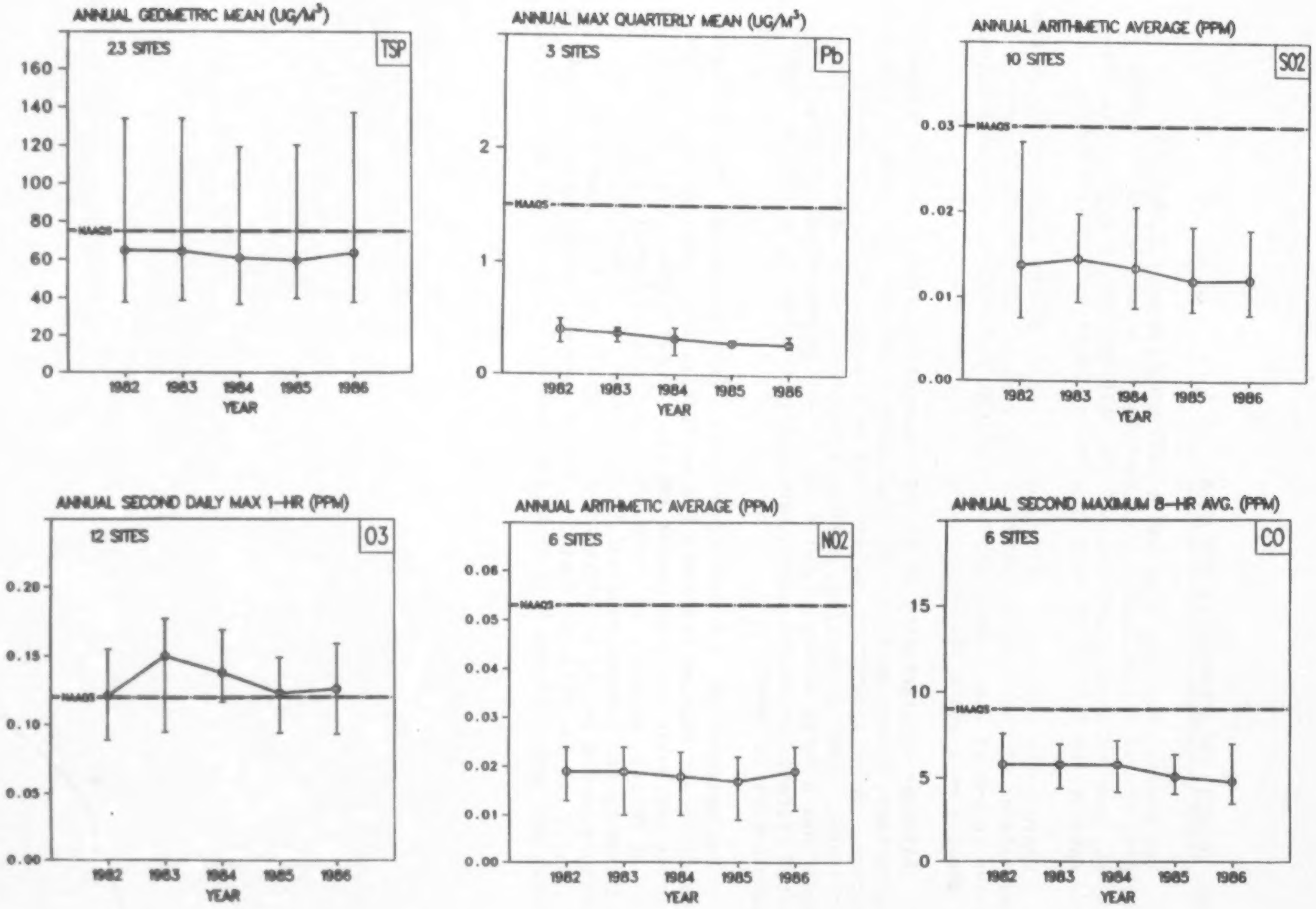

Figure 5-10. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the St. Louis, MO-IL Urbanized Area, 1982-1986.

5.10 DENVER, COLORADO URBANIZED AREA

The Denver urbanized area had a 1980 population of 1,352,070, including all of Denver County plus portions of Adams, Arapahoe, Boulder, Douglas, and Jefferson Counties. At the maximum boundaries, the urbanized area extends about 27 miles east to west and 26 miles north to south.

Denver, the capital of Colorado, is located at the western edge of the great plains of the midwest, with the Rocky Mountains just to its west. Denver is one of the highest cities in the United States, with an altitude of about 1 mile above sea level.

Although manufacturing is slight compared to other cities of similar populations, Denver does have manufacturing industries for rubber goods and luggage. Other industries include food processing, milling, printing, publishing, steel processing, machinery manufacture, and power generation. Denver has a large stockyard, with the largest sheep market in the United States. In recent years, many energy concerns have located their headquarters in Denver.

The meteorology in Denver is unique in that air masses from at least four different sources influence the weather in the urbanized area. These sources are polar air from Canada and the far northwest, moist air from the Gulf of Mexico, warm dry air from Mexico and the southwest, and Pacific air modified by the passage overland. Since Denver is a long distance from any moisture source and is separated from the Pacific by high mountains, it generally has low relative humidity and an average precipitation of only 14 inches per year. Figure 5-11 shows the trends graphs for the pollutants.

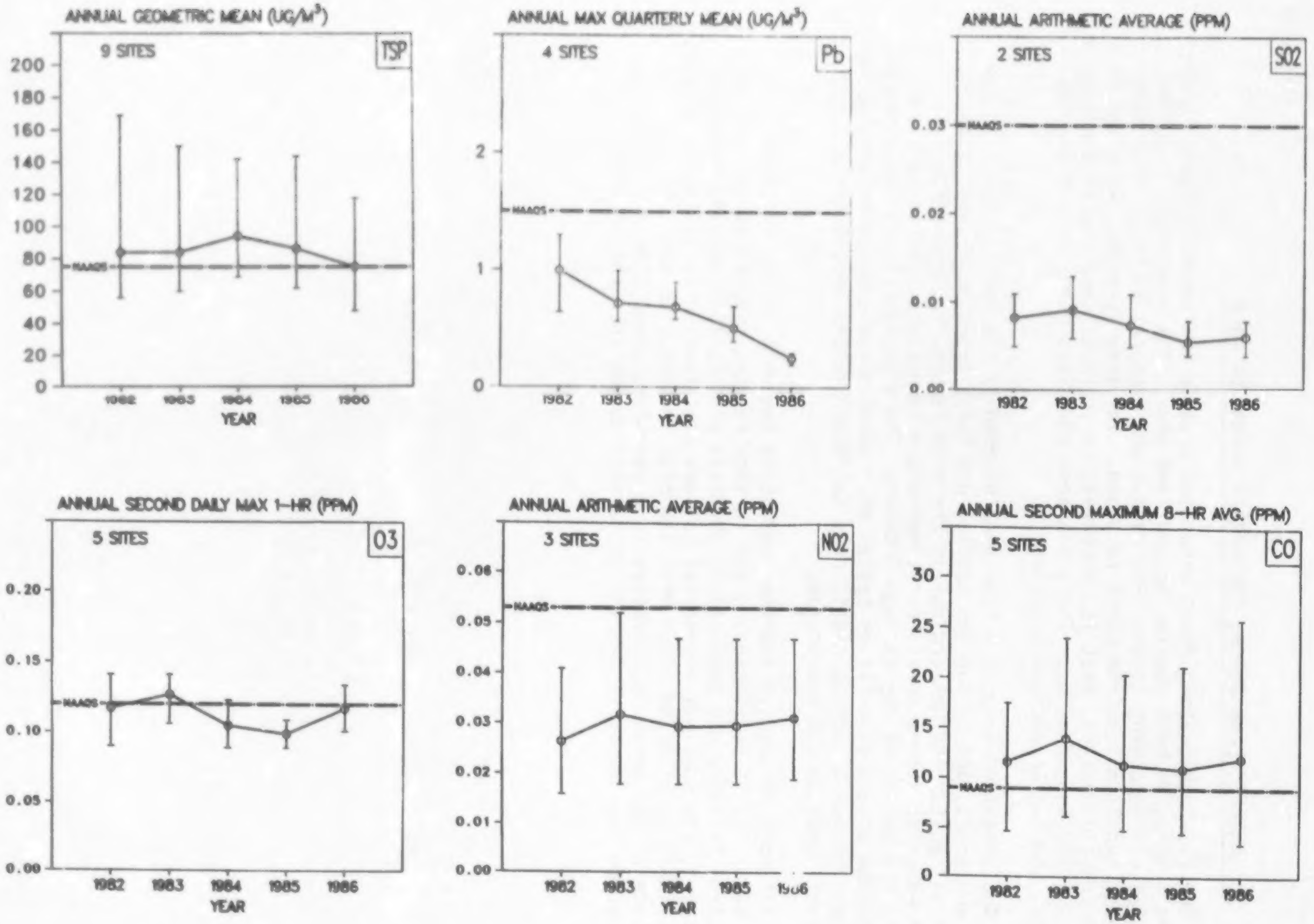

Figure 5-11. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Denver, CO Urbanized Area, 1982-1986.

5.11 LOS ANGELES-LONG BEACH, CALIFORNIA URBANIZED AREA

The Los Angeles-Long Beach urbanized area is the second largest in the United States, in both population and land area. The area has a population of 9,479,436 according to the 1980 census and measures 70 miles from east to west, and 71 miles from north to south. The area stretches 90 miles in its longest dimension, that is, northwest to southeast and contains approximately 1,700 square miles. The urban area comprises parts of Los Angeles, Orange, and San Bernardino Counties.

The urbanized area is a flat area bounded by the Pacific Ocean on the west and south, and by the San Gabriel and San Bernardino Mountains on the north and east. The meteorology in the area is complex, with frequent occurrences of strong persistent temperature inversions, particularly during the period of May through October. The wind pattern is dominated by a land-sea breeze circulation system that sometimes allows pollutants to be transported out to sea at night, only to return inland during the ensuing daylight hours on the sea breeze.

Although automotive sources contribute the bulk of the emissions, the area has a lot of manufacturing and service related industries, as well as petroleum refining and production, chemical plants, fuel burning electric utilities, and numerous industrial boilers contributing to pollution levels. The climate is mild and along with the high incidence of sunlight and latitude of the area, is conducive to a year-long ozone season. Figure 5-12 shows the trends of the six pollutants during the study period.

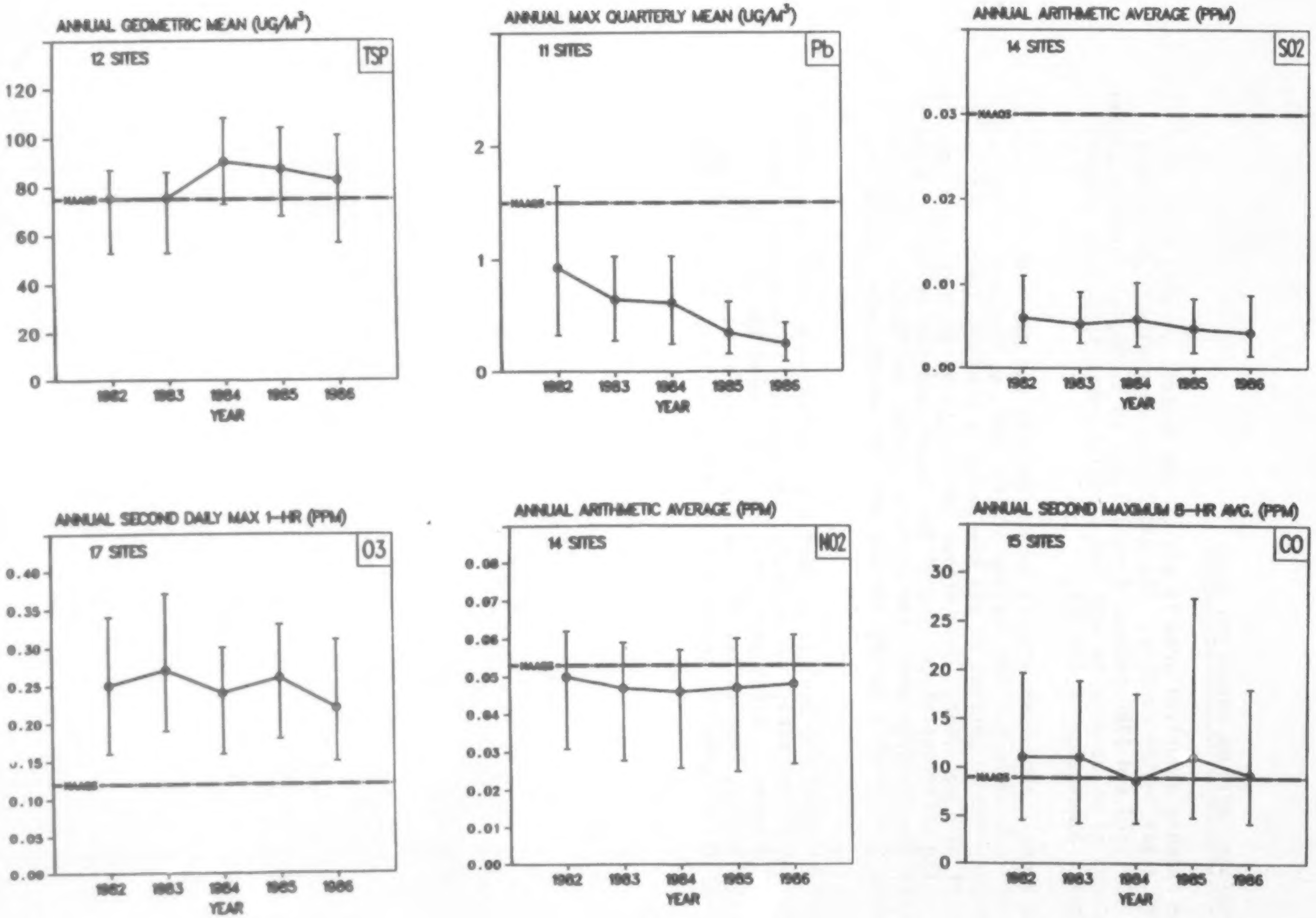

Figure 5-12. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Los Angeles - Long Beach, CA Urbanized Area, 1982-1986.

5.12 PHOENIX, ARIZONA URBANIZED AREA

The Phoenix urbanized area is one of the fastest growing major urbanized areas in the country. The population increased by 65 percent between the 1970 and 1980 census, from 863,357 to 1,409,442. The urbanized area extends 51 miles east to west and 32 miles north to south. Phoenix itself has a population of 789,704.

The Phoenix urbanized area is in the Sunbelt and has moderate to warm winters and hot summers. The "Valley of the Sun", as the area is called, averages sunshine 86 percent of all the possible sunshine hours, with only 7 inches of rain per year. Mountainous terrain is north, east, and south of Phoenix. The differential cooling of the desert and the mountains, coupled with a nighttime drainage wind flow pattern, causes pollutants to be transported away from Phoenix during the day only to return later during the night.

The "Valley of the Sun" is primarily a tourist area, with approximately 6 million annual visitors. Accordingly, the economy is primarily commercial and service oriented. Although tourism is high, among the 75 largest metropolitan areas, Phoenix has the smallest number of miles of freeways. Figure 5-13 illustrates the trends for all the pollutants in the urbanized area.

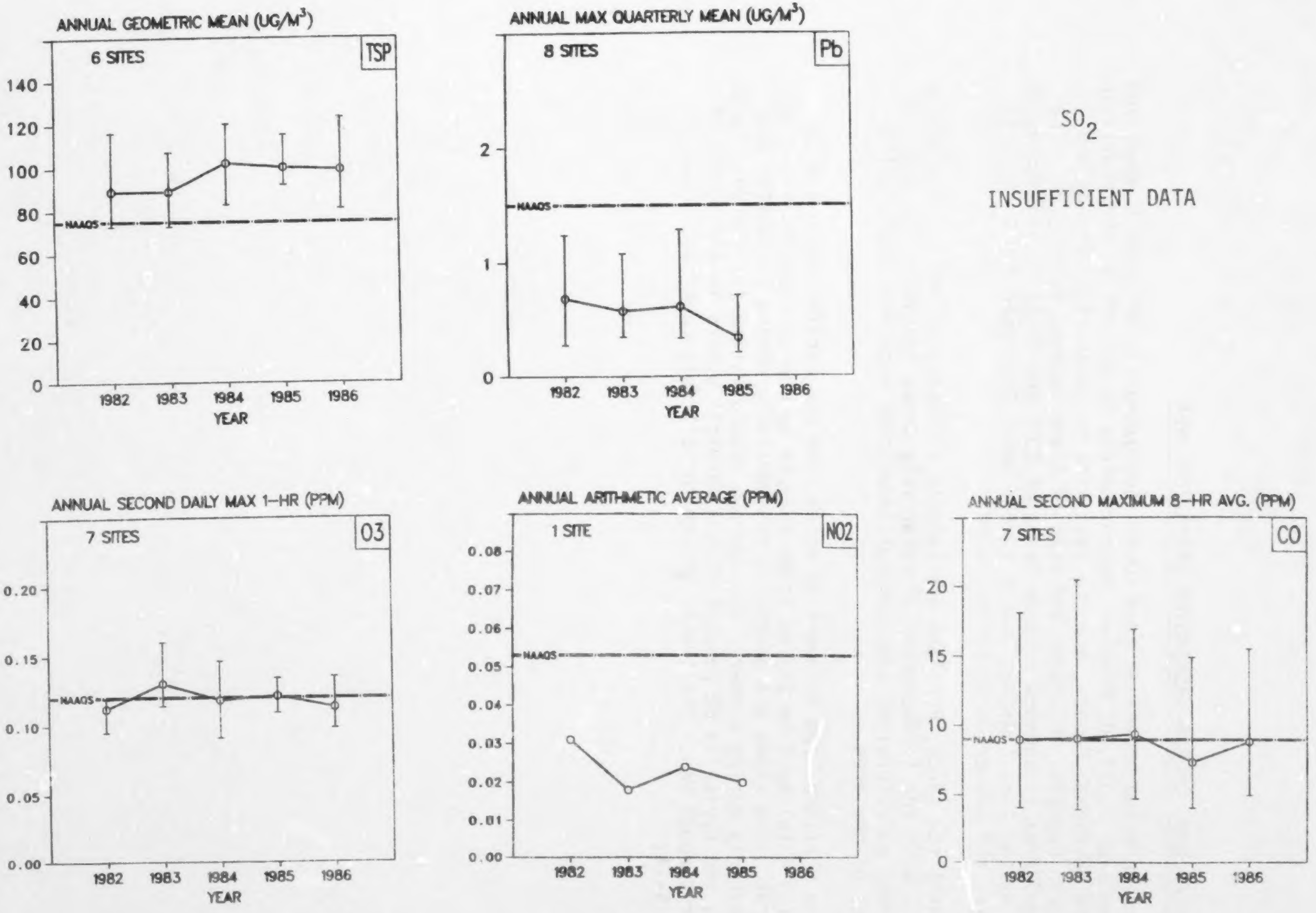

Figure 5-13. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Phoenix, AZ Urbanized Area, 1982-1986.

5.13 PORTLAND, OREGON-WASHINGTON URBANIZED AREA

The Portland urbanized area covers approximately 300 square miles and includes over 1,020,000 people. Approximately 50 percent of the population lives in Multnomah County, and the rest live in parts of Clackamas and Washington Counties in Oregon and part of Clark County, Washington. The urbanized area is bounded roughly by Hazel Dell and Orchards in Washington to the north; Forest Grove, Oregon to the west; Troutdale and Gresham to the east; and Beaver Creek to the south.

Until the 1940s, Portland was largely a commercial and transportation center. With the introduction of relatively cheap hydroelectric power in the 1940s, metallurgical and chemical industries augmented the ongoing commerce of the area.

The Portland area is about 65 miles from the Pacific Ocean and is partially shielded from the maritime climate by the surrounding hills and mountains. The winds are generally southeasterly during the winter and northwesterly during summer. The average precipitation for the area is 37 inches, and typically 88 percent of the rainfall occurs in the months of October through May. The trends graphs for all pollutants are shown in Figure 5-14.

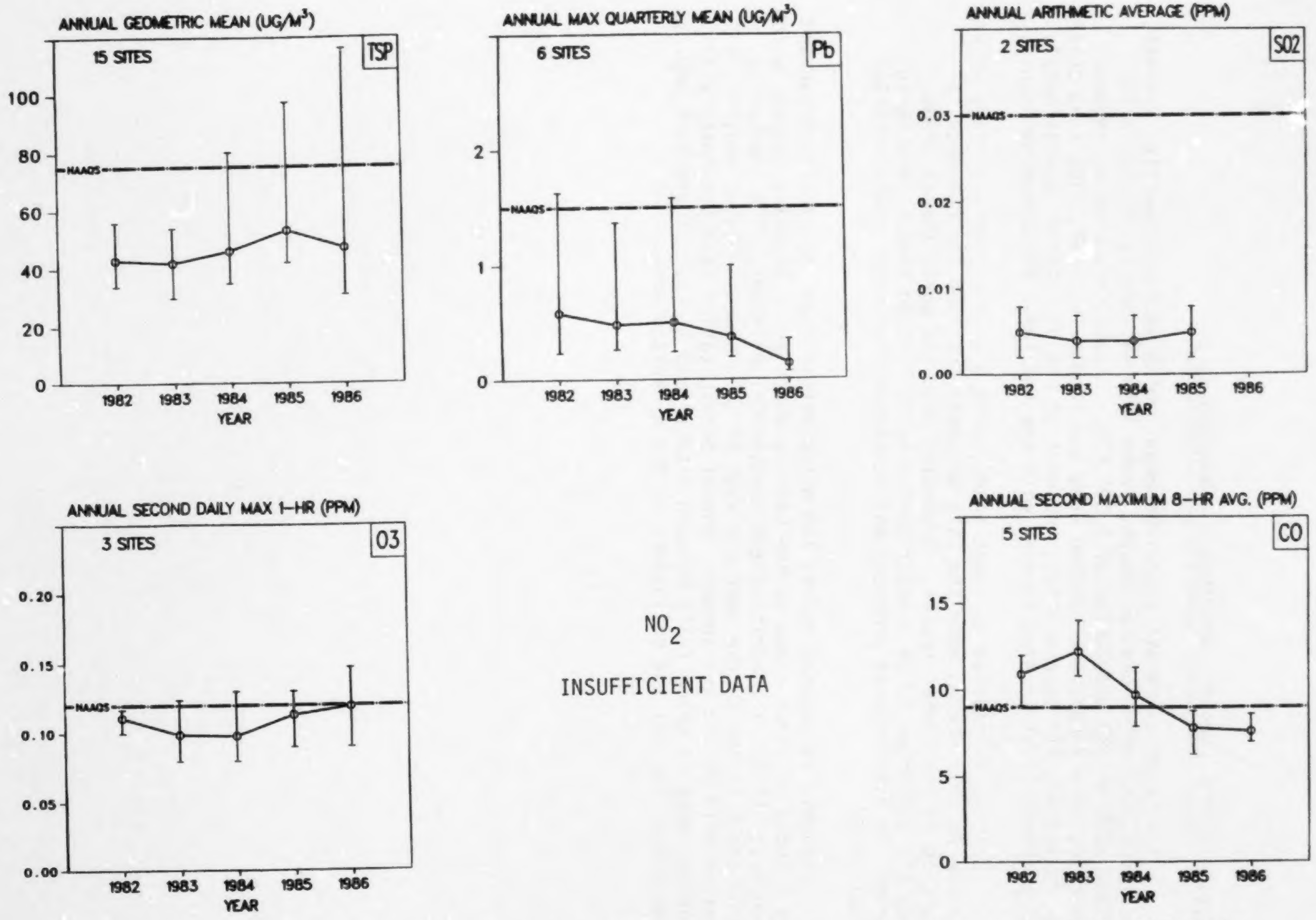

Figure 5-14. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Portland, OR-WA Urbanized Area, 1982-1986.

5.14 SEATTLE-EVERETT, WASHINGTON URBANIZED AREA

The Seattle-Everett urbanized area, which includes Seattle, Everett, Bellevue, and other smaller towns, ranks 20th nationally in population size, with a 1980 population of 1,391,535. Tacoma, even though adjacent to Seattle, is a separate urbanized area and is not included. The area covers approximately 410 square miles, and most of the population (approximately 85 percent) lives in King County, with the remainder in Snohomish County.

Seattle's location on Puget Sound, with a good harbor and ready access to the Pacific Ocean, made the city an ideal location for commerce to develop in the timber trades. Beginning with the early timber trade, Seattle has grown to be a major port city in foreign trade, leading to growth in manufactured products and development of other transportation facilities.

Seattle is located 100 to 150 miles inland from the Pacific Ocean and is bounded on three sides by the Cascade and Olympic mountain ranges, which moderate the Pacific maritime and continental climates. The sheltering from the climates to the east and west of the mountain ranges provides a rather mild winter and summer. Annual precipitation is approximately 34 inches, most of which falls between October and March. Figure 5-15 depicts the trends for all the pollutants in the urbanized area.

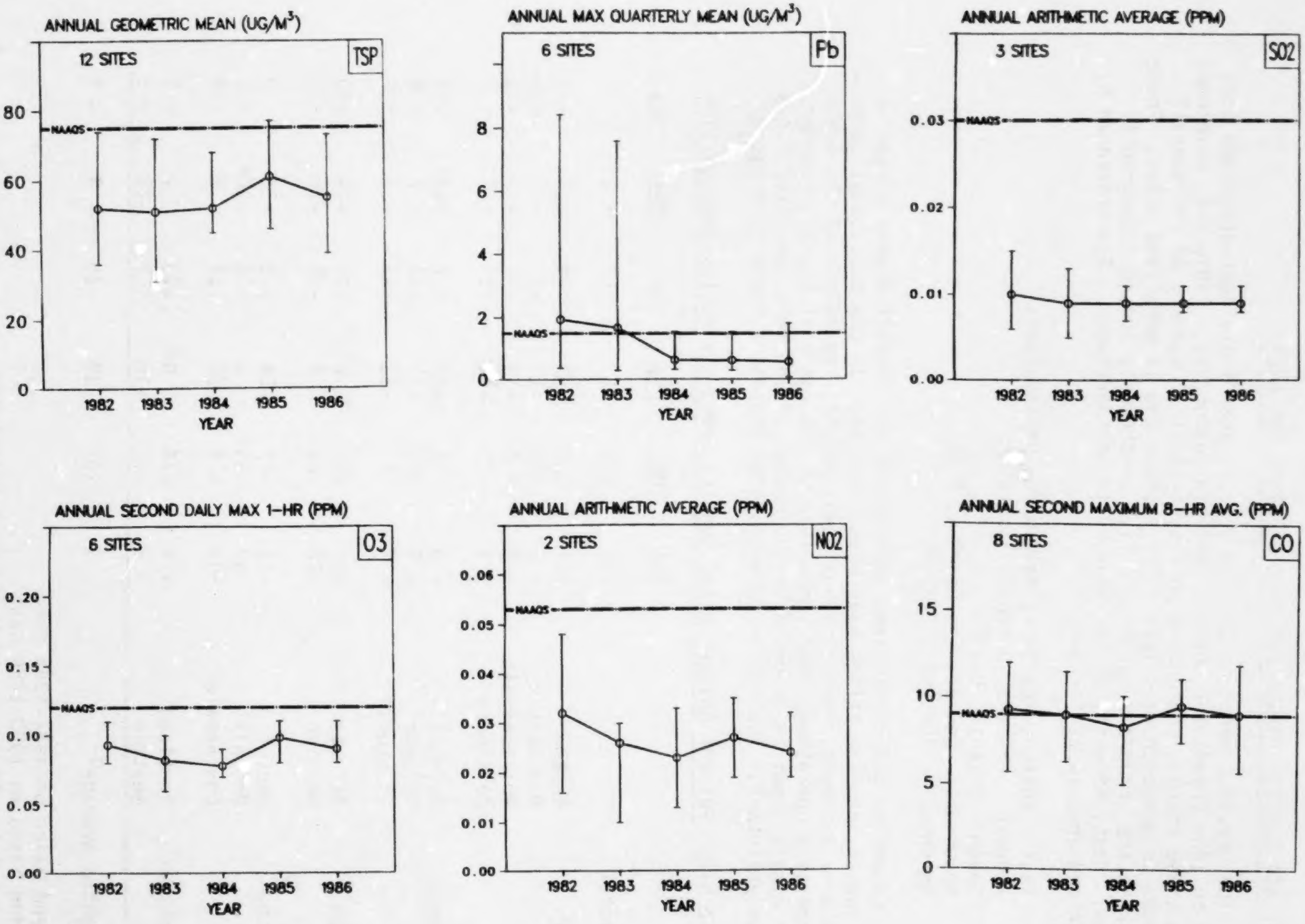

Figure 5-15. Air Quality Trends in the Composite Mean and Range of Pollutant-Specific Statistics for the Seattle, WA Urbanized Area, 1982-1986.

5.15 AIR QUALITY TRENDS FOR FIVE GEOGRAPHICAL AREAS

The previous sections include year to year individual urbanized area 1982 to 1986 trends for the six criteria pollutants. Table 5-2, developed from these trends, presents a pollutant-specific summary of the overall changes in concentration levels for each of the 14 urbanized areas. These 14 areas are grouped according to five arbitrarily arranged geographic areas: East, Midwest, South, Southwest, and Northwest. The breakdown by urbanized area is as follows:

East - Boston, New York, Baltimore, Philadelphia
Midwest - Chicago, Detroit, St. Louis
South - Atlanta, Houston
Southwest - Denver, Los Angeles, Phoenix
Northwest - Portland, Seattle

Composite geographic area averages of the overall 5-year change in air quality concentrations have been prepared. In the individual geographic area averages, each city has equal weight, regardless of the number of monitors operating. For comparison to the national trends, however, each city's input is weighted by the number of monitors operating for a given pollutant. The following discussion addresses these findings.

Table 5-2. Percent Change in Air Quality Trend Statistics 1982 to 1986

		TSP	Pb	SO_2	CO	NO_2	O_3
National		- 3	-68	-11	-13	- 1	- 4
East	Boston	- 1	-80	-15	-49	+13	- 4
	New York	- 8	-78	-17	-12	- 7	-13
	Philadelphia	- 3	- 8	-19	-12	- 4	- 8
	Baltimore	- 4	-79	-25	+14	+ 7	- 5
Midwest	Detroit	- 9	-74	-33	- 2	+10[a]	-20
	Chicago	- 5	-63	-11	-43	- 7	- 9
	St. Louis	- 2	-57	-12	-17	- 3	+ 4
South	Atlanta	+17	-85	0[b]	-27	+19	+20
	Houston	-28	-81[c]	7	- 5	-10	-12
Southwest	Denver	-11	-77	-26	+ 3	+18	0
	Phoenix	+11	-64[a]	-	- 2	-36[a]	+ 1
	Los Angeles	+10	-74	-30	-16	- 5	-14
Northwest	Portland	+ 9	-76	0[a]	-30	-	+ 7
	Seattle	+ 6	-71	-10	- 3	-25	- 3
Weighted Average[d]		- 5	-69	-18	-15	- 4	- 7

[a] Trend based on 1982-1985 data

[b] Trend based on 1983-1986 data

[c] Extrapolated 5-year trend based on 4-year trend

[d] Weighted by number of monitors in each city for comparison to national average

5.15.1 TSP Trends

The trend of the weighted average of the 14 cities trend of 5 percent is similar to the nation's downward trend of 3 percent during the 1982 to 1986 period. On a region-specific basis, the East, Midwest, and South had decreasing trends of 4 percent, 5 percent, and 6 percent, respectively, while the Southwest and the Northwest had increasing trends of 3 and 8 percent, respectively. However, the TSP trend reported last year for the 1981 to 1985 time period shows a major change from the 1982 to 1986 period. The 1981 to 1985 national trend showed a decrease of 18 percent, and the 14 city weighted average showed a decrease of 17 percent, compared to the 1982 to 1986 5-year drops of 3 and 5 percent, respectively. The last year that glass fiber filters were used was 1981, which may have biased the data high because of artifact formation.[2] In 1982, filters were used which eliminated the artifact formation. The decrease in the national TSP levels from 1981 to 1982 was 14 percent. This 14 percent decrease is of almost the same magnitude as the difference in the drop between the 1981 to 1985 trend and the 1982 to 1986 trend. Such situations illustrate the need to evaluate the conditions of the beginning or base year on a short term trend analysis. Although the 14 city weighted average trend was similar to the national average trend, the individual cities varied from a plus 17 percent in Atlanta to a minus 28 percent in Houston. The decrease in Houston is a consistent annual decrease occurring over at least the last 5 to 6 years. The increase in Atlanta has all occurred in the last year and is perhaps more heavily influenced by meteorology.

5.15.2 Pb Trends

The national trend for lead shows a 68 percent decrease, and the 14 city weighted average shows a 69 percent decrease. On a regional basis, the consistency is remarkable as well. The East and Midwest had decreasing trends of 61 percent and 65 percent, respectively, the South had an 83 percent decrease, the Northwest a drop of 74 percent, and the Southwest a 71 percent drop. The only city to deviate significantly from the norm was Philadelphia, which showed a decrease of only 8 percent for the 1982 to 1986 period. One site in Philadelphia is a source oriented site located near a plant which manufactures lead oxide pigment for paint. If this site is eliminated from the analysis, the remaining 6 sites, traffic oriented, still show only a 12 percent decrease. However, one of these remaining sites shows an increase of 146 percent between 1982 and 1986. This site is downwind of a major interstate highway, and major construction has occurred in the vicinity and will continue in the vicinity over the next few years. It is suspected that the construction activity is causing the reentrainment of dust containing deposited Pb particles, which would account for the increasing Pb levels monitored at this site. If this site is also eliminated from the analysis, the remaining 5 traffic oriented sites reflect a decrease of 53 percent, which more closely follows the national drop of 68 percent.

5.15.3 SO_2 TRENDS

The weighted average of the 14 cities showed an 18 percent decrease compared to an 11 percent decrease in the national average. The East and Midwest both had a 19 percent decrease. The Southwest exceeded the national trend with an average decrease of 29 percent, while the Northwest and the South had substantially lower decreases of 5 percent and 4 percent, respectively. While none of the individual cities had a positive trend over the time period, 2 cities, Portland and Atlanta, showed no change in SO_2 levels. These cities are among the cities having the lowest measured SO_2 averages of the 14 cities studied.

5.15.4 CO TRENDS

Similar to the other pollutant primarily attributable to motor vehicle emissions, lead, the trends in CO are remarkably uniform within each geographic area when compared to the national average. The East, Midwest, South, Southwest, and Northwest areas decreased, respectively, by 15, 21, 16, 10, and 17 percent. The overall weighted average decrease of 15 percent is close to the national composite average decrease of 13 percent. Of the individual cities, Boston and Chicago stand out as examples of exceptionally large decreases, 49 percent and 43 percent, respectively. The 49 percent decrease in Boston is attributable to the abnormally high CO levels recorded in 1982, and this overshadowed even a modest increase between 1985 and 1986. Chicago, however, has been showing a strong decrease each year since 1983, and 1986 continues this trend.

On the other hand, the only two cities to experience an increasing trend over the 1982 to 1986 time period, Baltimore with 14 percent and Denver with 3 percent, also experienced increases in CO levels during the 1985 to 1986 period. The State of Maryland pointed out, however, that the Baltimore data indicated that the number of exceedances at the worst site decreased by 67 percent over the 1982 through 1986 period and the apparent increase in the second maximum 8-hour period represents the severity of meterological inversions rather than a general increase in CO levels.

5.15.5 NO_2 Trends

Data for NO_2 trends analyses continue to be sparse in many of the cities used. Although the 14 city weighted average trend of minus 4 percent compares favorably with the national trend decrease of 1 percent, the range in the trend values for the individual cities spans from a decrease of 36 percent to an increase of 19 percent. These extreme variations are observed only in those cities having 3 or fewer monitors. The range of the trend values from the 6 cities having 5 or more NO_2 monitors is much less, from 0 to a 10 percent decrease. On a geographical basis, the East had a 2 percent increase, the Midwest had no change, the South a 5 percent increase, and the Southwest a drop of 8 percent. The Northwest, which was based on 1 city, Seattle, with only 2 monitors, had a 25 percent decrease.

5.15.6 O_3 Trends

The national composite trend of a minus 4 percent is exceeded by the 14 city weighted average trend of 7 percent. The East and the Midwest lead the decrease with 8 percent. The South had a 4 percent increase, the Southwest a 4 percent decrease, and the Northwest an increase of 2 percent.

A close inspection of the trend graphs for the 14 cities shows that 1983 was an unusual year that favored elevated ozone levels. The reasons for this were elaborated in prior trend reports, but meteorology, primarily the elevated summer temperature and available sunshine, was the prime contributor. Twelve of the 14 cities showed a substantial increase from 1982 to 1983, while the two cities in the northwest recorded minor decreases. In 1984, the meteorological conditions were more typical, and all 14 cities showed a decrease. The average increase between 1982 and 1983 of the 14 cities was 12 percent, and the decrease between 1983 and 1984 was 12 percent. This change is three times the average decrease of 4 percent for the 14 cities between 1982 and 1986. With 1983 serving as the base year of a 5 year trend period, the trend could show a misleadingly high level of improvement. The following year, either a lower level of improvement or a possible degradation in air quality may be indicated merely by changing the base year.

5.16 REFERENCES

1. 1980 Census of Population, PC 80-1, U. S. Bureau of Census, Washington, DC, December 1981.

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